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MINUTES AND PROCEEDINGS

of the fourteenth meeting of the

ARMY - NAVY - OSRD VISION COMMITTEE

11-12 September 1945

Medical Research Laboratory
U. S. Submarine Base
New London, Conn.

COPY NO. 163

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U. S. Armed Forces - NRC Vision Committee
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ARMY - NAVY - OSRD VISION COMMITTEE

MINUTES

Fourteenth Meeting
Medical Research Laboratory
U. S. Submarine Base
New London, Conn.
11-12 September 1945

The following were present:

ARMY	AAF	(M)Major E. A. Pinson
		(A)Lt. A. Chapanis, Aero Medical Laboratory, Wright Field
		Col. Merrill J. Reeh, School of Aviation Medicine, Randolph Field
		Lt. Col. P. R. McDonald, Office of the Air Surgeon
		Lt. Col. John L. Matthews, School of Aviation Medicine, Randolph Field
		Capt. Harry A. Pfingst, School of Aviation Medicine, Randolph Field
		Capt. R. G. Scobee, School of Aviation Medicine, Randolph Field
		Lt. Earl L. Green, School of Aviation Medicine, Randolph Field
		Dr. Conrad Berens, Consulting Ophthalmologist to the Air Surgeon
	AGF	(M)Col. Paul A. Reichle
	AGO	Capt. C. P. Sparks, Personnel Research Section
	Ord	(A)Mr. John E. Darr
	SG	(M)Major Trygue Gundersen
		(A)Lt. Col. F. S. Brackett
		Major L. B. Roberts, Armored Medical Research Laboratory, Fort Knox
	WDLO	Lt. Col. H. Noble, War Dept. Liaison Office with NDRC
NAVY	BuAer	(A)Lt. Harry London
	BuMed	(A)Comdr. R. H. Peckham
		Lt. Harry J. Older, Aviation Psychology Branch
		Dr. Franklyn Burger, Research Project X423
	BuOrd	(M)Comdr. S. S. Ballard
		(A)Lt. Nathan H. Pulling
	BuShips	(CM)Comdr. C. Bittinger
		Comdr. Dayton R. E. Brown, Camouflage Section
		Lt. Comdr. R. M. Langer, Physics Research Section
		Lt. (jg) F. B. Loomis, Camouflage Section
		Miss Marion M. Sandomire, Research & Standards Branch
		Mr. D. F. Windenburg, The David Taylor Model Basin
	NMRI	Comdr. R. H. Lee
	NRL	(M)Dr. E. O. Hulburt
		(A)Dr. Richard Tousey

NAVY	ORI	(M)	Comdr. H. G. Dyke
			Comdr. Arthur J. Vorwald
	S C Bd	(M)	Lt. Comdr. George W. Dyson
	SubBase	(M)	Capt. C. W. Shilling
		(A)	Lt. (jg) W. S. Verplanck
			Lt. Comdr. J. H. Sulzman, Medical Research Dept.
			Lt. Ellsworth B. Cook, Medical Research Dept.
			Lt. Dean Farnsworth, Medical Research Dept.
	NAS		Lt. Henry A. Imus, Naval Air Station, Pensacola, Fla.
			Lt. L. L. Langley, Naval Air Station, Alameda, Calif.
	ORG		Dr. Edward S. Lamar, Operations Research Group
OSRD	NDRC		Dr. Lloyd H. Beck, Brown University, Contract OEMsr-1229
			Mr. H. Richard Blackwell, L. C. Tiffany Foundation
			Dr. Clarence H. Graham, Brown University
	APP	(M)	Dr. H. K. Hartline
		(M)	Dr. Charles W. Bray
	CMR	(M)	Dr. Walter R. Miles
			Dr. C. J. Warden, Columbia University
			Dr. Donald Scott, Jr., University of Pennsylvania
	OSRD	(M)	Dr. Donald G. Marquis
			Dr. I. S. Gardner, National Bureau of Standards
			Dr. David L. MacAdam, Eastman Kodak Company, Research Laboratory

Tuesday, 11 September

A tour of the Submarine Base, with demonstrations of the selection and training programs for interior voice communication, look-out, and recognition, was arranged for members and guests not attending the scheduled meeting of the Subcommittee on Procedures and Standards for Visual Examinations.

1. The chairman called for corrections or alterations in the Minutes and Proceedings of the thirteenth meeting. There were no corrections.

2. Dr. Miles presented a discussion of entoptic plotting of the macular area. 15*

3. Comdr. Dayton Brown discussed developments in naval camouflage and proposed a resolution for adoption by the Committee designed to insure that a program of vision and visibility research be included in any federal research program. 29

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* Numbers at the right refer to pages in the Proceedings on which the full report or discussion is presented.

Consideration of this resolution was postponed until Wednesday. After discussion, the resolution was revised and it was

VOTED: that the Army-Navy-OSRD Vision Committee will consider it one of its primary duties to determine visual problems on which research is needed and to foster the devotion of adequate funds, facilities and personnel to research for the solution of those problems.

4. Dr. C. H. Graham reported on problems in the design of rangefinder reticles. 34

5. Design and tests of rifle sights.

   A. Comdr. Dyke discussed briefly some problems involved in the design of rifle sights. 37

   B. Mr. Darr commented on technical requirements for rifle sights in Army Ordnance. 37

   C. Dr. C. J. Warden presented a paper on the results of testing various rifle sight designs. 63**

Half the members and guests participated in the Tuesday night binocular testing field trials (<u>Minutes</u>, twelfth meeting, item 7, pg. 11). Others inspected a captured German submarine.

<u>Wednesday, 12 September</u>

Demonstrations of the Visibility Theater model and of color vision information and tests were observed.

6. Dr. Marquis presented the report of the Subcommittee on Procedures and Standards for Visual Examinations. Three papers presented to the Subcommittee are appended: 39

   A. Testing Vergence and Phoria. Capt. R. G. Scobee 41

   B. Comparisons of Measures of Lateral Phoria. Lt. Comdr. J. H. Sulzman 48

   C. Phoria Testing at Pensacola. Comdr. B. J. Wolpaw 49

** Confidential Supplement.

The Committee

VOTED: that the Subcommittee report be accepted, and that the manual Testing Heterophoria be distributed to Army and Navy centers for trial and comment.

7. Capt. Shilling introduced the discussion of the Visibility Theater model with a statement of its purpose and potential usefulness. 50

Lt. Comdr. Leavitt proposed a motion for discussion implementing the goals outlined by Capt. Shilling. After discussion, the motion was revised, and it was

VOTED: that the Army-Navy-OSRD Vision Committee believes it to be valuable and desirable for the Navy Department to provide facilities for visual research including building and operating a large-scale permanent visibility theater as a means of continuing active study of visual problems.

A Subcommittee on the Visibility Theater was appointed. 52
A statement prepared by the Subcommittee embodying the Vision Committee discussion is appended.

8. The continuation of the Army-Navy-OSRD Vision Committee beyond the war-emergency period was discussed. Comdr. Dyke outlined the activities of the Executive Committee in this regard, and Dr. Marquis discussed possible mechanisms for its continuation.

After discussion, the Committee

VOTED: that the Army-Navy-OSRD Vision Committee should be continued during peacetime.

VOTED: to approve a revised committee organization to be made up of representatives from the bureaus and offices of the Army and Navy and from the National Research Council and to be known as the Army-Navy-NRD Vision Committee.

VOTED: that the negotiation of a contract between the Office of Research and Inventions, Navy Department, and the University of Michigan, for continuing the work of the Committee, be approved.

9. Symposium on German developments in vision and optical devices.

A. German Visual Devices. Comdr. A. J. Vorwald 55

B. Optical Devices in German Ordnance. Comdr. S. S. Ballard 57

C. German Goggles, Sunglasses, and Dark Adaptometer. Major E. A. Pinson 58

D. Description of Zeiss Sunglasses found aboard a Captured German Submarine. Lt. Dean Farnsworth 59

E. Some notes on Visual Devices and Procedures observed on new German Submarines. Lt. (jg) W. S. Verplanck 65**

F. German Variable-Power Telescope. Lt. Harry London 61

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ARMY - NAVY - OSRD VISION COMMITTEE

PROCEEDINGS

Fourteenth Meeting
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2. ENTOPTIC PLOTTING OF THE MACULAR AREA

Dr. Walter R. Miles

Introduction

Under suitable conditions of illumination the yellow spot of the retina may be seen moderately well outlined in the visual field. This entoptic picture of the macula lutea surrounding the point of fixation claimed the attention of several students of vision in the nineteenth century. It appears to merit reinvestigation with the objective of exploring its possibilities for usefulness as a visual measure of the form and dimensions of the fovea. Although the phenomenon has been independently discovered by many, Maxwell[1] has received credit for the first painstaking investigation of it. His brief classical statement runs as follows:

> "When observing the spectrum formed by looking at a long vertical slit through a simple prism, I noted an elongated dark spot running up and down in the blue, and following the motion of the eye as it moves up and down the spectrum, but refusing to pass out of the blue into the other colors. It was plain that the spot belonged both to the eye and to the blue part of the spectrum. The result to which I have come is, that the appearance is due to the yellow spot on the retina. . . . The most convenient method of observing the spot is by presenting the eye in not too rapid succession, blue and yellow glasses, or, still better, allowing blue and yellow papers to revolve slowly before the eye. In this way the spot is seen in the blue. It fades rapidly, but is renewed every time the yellow comes in to relieve the effect of the blue."

1/ J. C. Maxwell. On the unequal sensibility of the foramen centrale to light of different colors. Report of Brit. Assoc., 1856, 2, 12.

This phenomenon received considerable attention from Helmholtz[2], who found, as others have noted, that he could observe it without the aid of filters by closing his eyes for a moment and then opening them towards the evening sky, whereupon, he says, "the observer will see the non-vascular halo very distinctly for some time, often too the fovea centralis in its interior as a little brighter spot of pure blue, pretty sharply outlined."

Helmholtz's summary of his own and the observations of others on the entoptic appearance of the macula was followed by important investigations of Gullstrand[3] and Dimmer[4], but within the last half century very little further work seems to have been devoted to this subject. Gullstrand worked with various liquid filters, usually green and blue, and found that by suitable dilution of these he could see a small spot in the middle of the larger spot. The smaller spot he identified as the entoptic fovea and the larger as the entoptic macula. At a projection distance of 30 cm. the measurement of the macula subtended 15 mm., thus giving about 3°. He found that afterimages of the macular picture were observable following removal of filters. Dimmer worked with a larger range of filters and more consistently with the afterimage as a part of the entoptic appearance, defining the borders and content of the area, but did not formulate his methods in any standard way for general use.

<u>Filter</u> <u>requirements</u>

The unequal response of the photoreceptors lying behind the macula lutea and those surrounding it must be observed quickly when stimulated with white light, since the brightness inequality is promptly compensated by some process which may be called retinal adaptation. When selective radiation is used for stimulation, the darkened macular area endures longer but dies away fairly rapidly, in some subjects very promptly. It was to combat this retinal adaptation that Maxwell recommended alternate use of blue and yellow glasses, which serves to refresh the entoptic experience. If the phenomenon is to be measured or plotted with success by others than expert observers, it must be made to persist. It occurred to the writer that in place of using filters of complementary colors, there were reasons for expecting a better result by using a

2/ Helmholtz's Treatise on Physiological Optics, English translation with additions, ed. Southall, publ. 1924-25 by The Optical Society of America; see Vol. II, 301-304.

3/ A. Gullstrand. Die Farbe der Macula centralis retinae. Arch. f. Ophthalm. (Graefe), 1906, <u>62</u>, pp. 1, 378.

4/ F. Dimmer. Die Macula lutea der menschlichen Netzhaut und die durch sie bedingten entoptischen Erscheinungen. Arch. f. Ophthalm. (Graefe), 1907, <u>65</u>, 513-544.

pair of filters matched for over-all transmission, one colored, the other neutral. By mounting these filters side by side so that the eye or eyes could look through first one and then the other, full advantage could be expected from the afterimage seen through the neutral filter following stimulation through the colored one. Alternation of the filters at intervals of 5 or 10 sec. should give an almost continuous display of the macular area, showing the same boundary or boundaries, first in one color and then in the afterimage of that color. These assumptions proved to be substantially correct. For most subjects the morphology appearing within the projected area seemed to be about equally clear in both the primary and the afterimage phases. In some it seemed more clear in the afterimage phase. This may be influenced by the order of experience, since subjects look through the colored filter first in initiating the entoptic image and then, on shifting to the neutral, the afterimage comes as a distinct surprise to most observers.

It may be assumed that the region of highest spectral absorption characteristic of the macular pigment would be determining for the filter needed to call forth the most striking delineation of the macular area. There are available some data on which to proceed. Sachs[5] reports measurements of the absorption of the macular pigment of the isolated human retina for different wave lengths in nine cases. The absorption was unmeasurably small for sodium light and light of greater wave lengths. But by gradual steps absorption was found to become greater as the violet end of the spectrum was approached. In the case most completely studied, 29.7 per cent absorption was found for 510 mμ., 34.7 at 500, with gradual increases up to 49 per cent absorption at 422.6 mμ (line g) beyond which Sachs reports no other measurements. Kohlrausch[6] has reported similar absorption data for the macular pigment. These tend to be a little higher than those of Sachs in the region 560 to 500 mμ, but are very close to the former results in the 400's and show a final value of 44 per cent absorption for wave length 440 mμ. Recent results of Wald[7], determined by threshold measurements with a 1° test-field centrally fixated and illuminated with different wave lengths, indicate that for the mean of 10 subjects the macular pigment absorbs about 60 per cent of the light of wave lengths 430-490 mμ incident on the fovea. Relative to the indicated absorption at this spectral region, there was 0 absorption at 600 mμ and beyond in the red. Wald includes in his Fig. 4 the absorption spectrum of a partially purified preparation of xanthophyll extracted from human maculas which shows a maximum absorption at about 460 mμ. Foveal thresholds were not measured at this precise wave length, but threshold values determined for 436 mμ and 492 mμ fall on

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5/ M. Sachs. Arch. ges. Physiol., 1891, <u>50</u>, 586.

6/ A. Kohlrausch. Ber. ges. Physiol., 1923, <u>22</u>, 495.

7/ G. Wald. Human vision and the spectrum. Science, 1945, <u>101</u>, 653-658.

the xanthophyll curve, and the 436 value shows a greater loss than for 492 mμ. The data at hand thus appear to favor a violet-blue filter with maximal transmission between 420 and 440 mμ. Wald's maximal threshold loss, found for 436 mμ, happens to fall at a point within this range. On the other hand, his visual estimates appear to fit the macular xanthophyll curve which would dictate the region 450-470 as optimal for our filter requirement. Actually, blue filters which fall in either range or between these two ranges may be fairly satisfactory for revealing the entoptic macula.

In selecting a filter for use in revealing the macula it has seemed obvious that it should be deep blue. But, in addition to selection of the right blue, there is still an improvement that should be possible by taking advantage of the repeated observation that the macular pigment does not appreciably absorb deep red. The optimal filter indicated should therefore be a purple dichroic passing deep violet-blue and deep red. This should produce a macular spot that is both darker and redder than its surrounds in the visual field. The red light passed by the filter will, in the afterimage phase, produce a green color that should add distinction to the picture which the observer sees on looking through the neutral filter. This assumption was borne out in trials with several subjects.

At the time of initiating study on the feasibility of macular plotting, the filters which the writer found in his possession that most nearly represented the desirable combination were some specimens of a light experimental form (No. W. 1635) of the dichroic filter, Wratten No. 97[8]. The latter proved much too dark for securing good results, while 1635 gave fairly good entoptic pictures of the macula against the sky or against snow. A neutral gray filter, Wratten No. 96, density 1.0, matched the over-all transmission of 1635 satisfactorily so that in passing from one to the other the observer was not conscious of a large difference in brightness and saw a clear afterimage. The two filters were mounted side by side forming a flat split-field disc or rectangular window[9]. For sake of simplicity, ordinary 2 x 2 in. slide binders with good cover glasses, 35 x 40 mm., held by a cardboard frame, were used as mountings. The opening in these frames was 24 x 34 mm. The frame therefore gave a clear view through an area of 17 x 24 mm. for each filter. A pair of such slides attached to a piece of cardboard served as an experimental spectacle for viewing the macular projection binocularly.

8/ These specimens had been kindly supplied the writer in another connection by Mr. E. M. Lowry, physicist, Eastman Research Laboratory, on April 6, 1943.

9/ Such arrangements have been used for camouflage detection but not previously, so far as the writer is aware, for the purpose of facilitating the observation of visual afterimages or of visual contrast.

These split-field filter units, made of W. 1635 and W. 96, D. 1.0, were demonstrated to several members of the Vision Committee at the time of the Rochester meeting and earlier to the aviation physiologists of the Army Air Forces. This filter combination, while providing a convincing demonstration for most subjects against the sky as background, failed or nearly failed with some and was not very satisfactory when used against the artificially illuminated window of an X-ray viewing box equipped with fluorescent lamps. The transmission characteristics of experimental filter W. 1635 are shown in the solid line in Fig. 1. The maximal transmission at the blue end of the spectrum was found at 490-500 mμ with a cut-off towards the middle of the spectrum at 540 mμ. Beyond 620 mμ transmission in the red was found to rise sharply and to approximate 85 per cent at 700 mμ.

In an effort to find a more satisfactory filter than W. 1635 for use with fluorescent light, resource was had to sample albums of common theater gelatines, since colored filters of better quality were not available at the time. Eighteen slides were prepared and tried out comparatively by two observers. In judging these filters, the chief criterion was striking contrast between the projected macular area and the surrounding field in the primary phase, that is, when looking through the colored portion of the filter. Both observers independently agreed in placing Rosco No. 28 (dark purple) at the top as providing the best results among the filters examined. Transmission characteristics for Rosco No. 28 are shown in the dotted curve of Fig. 1. The high point for transmission in the blue fell between 420 and 430 mμ, with a cut-off at about 515 mμ. This filter was more selective in its red transmission than was found for W. 1635. Neutral W. 96, D. 1.0, was used with Rosco No. 28 in securing the results here reported. This selection cannot be taken as a final choice, since undoubtedly other filters will become available before long for comparison. However, it probably approaches the optimal for such a filter for use under the observing conditions here adopted.

Macular plotting conditions.

The arrangements for plotting the macular area were simple ones. The subject was seated at a small table, and his head was supported by an adjustable chin rest. At the other end of the table an X-ray viewing box was placed at the proper height to serve as a tangent screen[10]. The distance from the observer's eye to the front of the illuminated window was set at 114.6 cm., so that a tangent distance on the screen of 20 mm. should equal 1° of visual angle. The window was illuminated by two fluorescent lights of daylight quality, and the light intensity at the middle of the field measured 35 f.c.

10/ The box used was Model D-V, Humphreys Roentgen Co.

About 1 f.c. of Mazda lighting from a ceiling fixture was incident on the window so that the surrounds of the box were not in complete darkness. A small cross inked on the glass at the center of the lower half of the window served as a preliminary fixation point. The upper half of the window was covered by translucent tracing paper ruled in millimeters with centimeters accentuated. These rulings were in blue-green ink and were quite faint as viewed against the brightness of the window. Two black dots were placed on the tracing paper, each dot 5 cm. up, 5 cm. in from the lower left hand and right hand ruled corners, respectively. These dots served as fixation points during the monocular plottings. After viewing the entoptic projection through the filters while fixating the cross in the lower half of the window, the subject was asked to draw a rough sketch of the figure seen. The experimenter then proposed that the position of various boundaries of this figure be determined for each eye separately while the figure was viewed surrounding the fixation point located on the plotting paper. A very thin pencil with well sharpened point was used by the experimenter who passed it along one radius from within the figure out toward the boundary and made a small mark where the subject reported it coincident with the boundary. Then the pencil point was passed from the outside toward the boundary. In this manner points were plotted at the top and bottom for the vertical axis and for the horizontal axis at the right and left borders of all areas observed. After the cardinal points had been plotted the subject was asked to sketch in the remainder of the picture on the chart, filling out the boundaries and other details. Notes included comments of the subject on smooth or scalloped edges, on petal-like structures, etc.; also his report on the color of the background, and of the macular picture and any defined parts of it, both in the primary phase and in the afterimage phase. He was repeatedly instructed to hold the fixation point carefully and to report the presence of any dark specks, spots, or blotches that might appear within the boundary of the macular picture or around it.

Subject personnel

The subjects in this preliminary experiment were 20 young men, ranging in age from 19 to 32. They were not selected on the basis of any visual test or other tests, and were quite untrained so far as the present type of observing was concerned.11/ Eleven of the subjects had

11/ The subjects were from a group of C.O.'s stationed at the Yale Medical School, who were cooperating in an experimental jaundice study. They were all in good health at the time these tests were conducted. Grateful acknowledgment is made for the services of Mr. Peter Bennett, a member of the C.O. group, who served as assistant and carried out the tests.

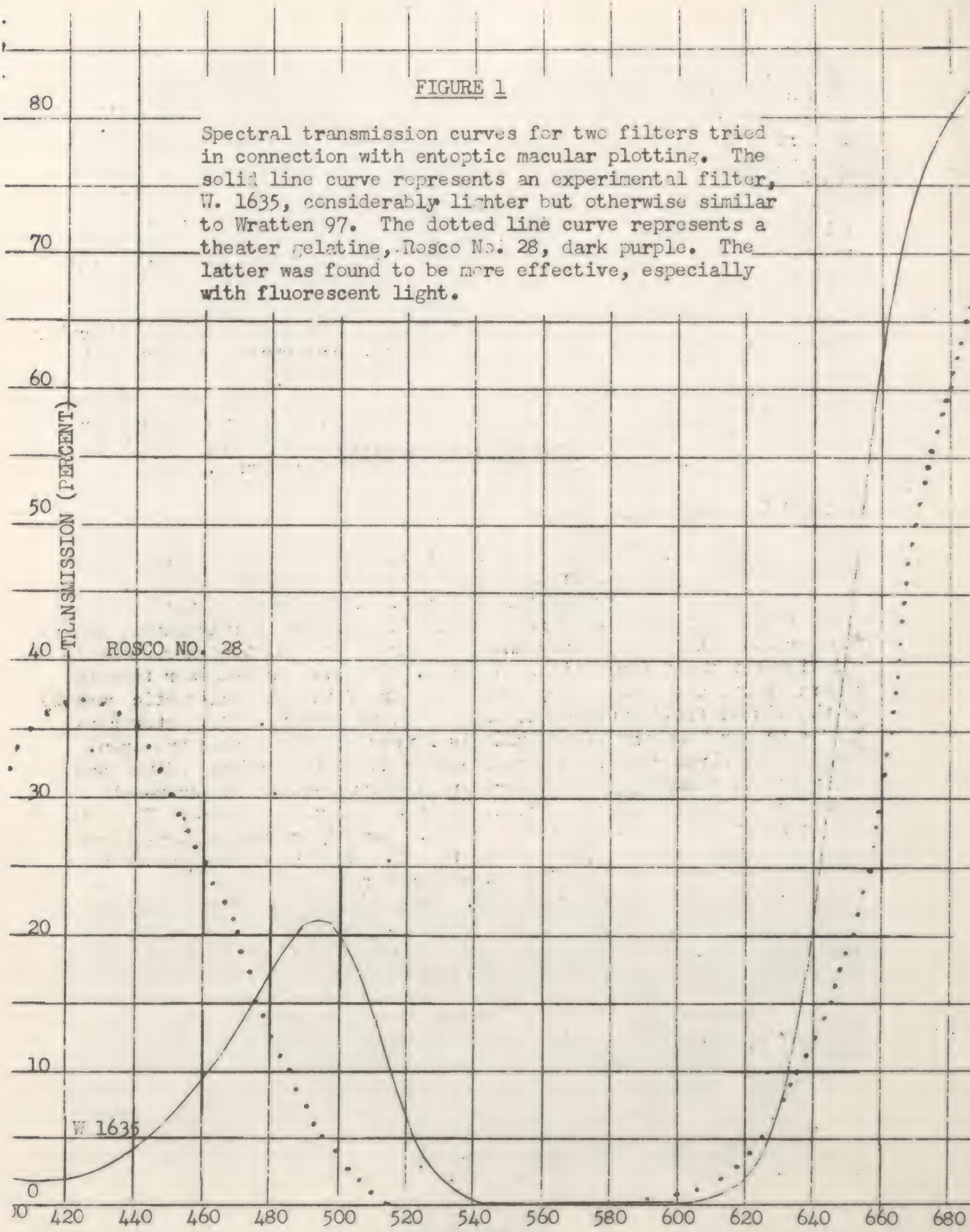


FIGURE 1

Spectral transmission curves for two filters tried in connection with entoptic macular plotting. The solid line curve represents an experimental filter, W. 1635, considerably lighter but otherwise similar to Wratten 97. The dotted line curve represents a theater gelatine, Rosco No. 28, dark purple. The latter was found to be more effective, especially with fluorescent light.

Date 2-15-45
Test No. 31152

WAVELENGTH W 1635
(millimicrons)

Color Measurements Lab.
Mass. Inst. of Tech.

sufficiently good vision that they needed no glasses; 9 subjects wore glasses. Subjects were examined one at a time in a large airy room with no daylight light. The subjects were examined during daytime, and no special attention was given to their light adaptation level. As a rule they came from other rooms in the building or adjoining buildings and were in the testing room several minutes before the plotting started. They came one at a time, the instructions were as indicated above, and the tests were limited to monocular presentation. The eye color of each subject was noted, but the number of men was not sufficiently large to warrant classifying the group in sub-divisions on this basis.

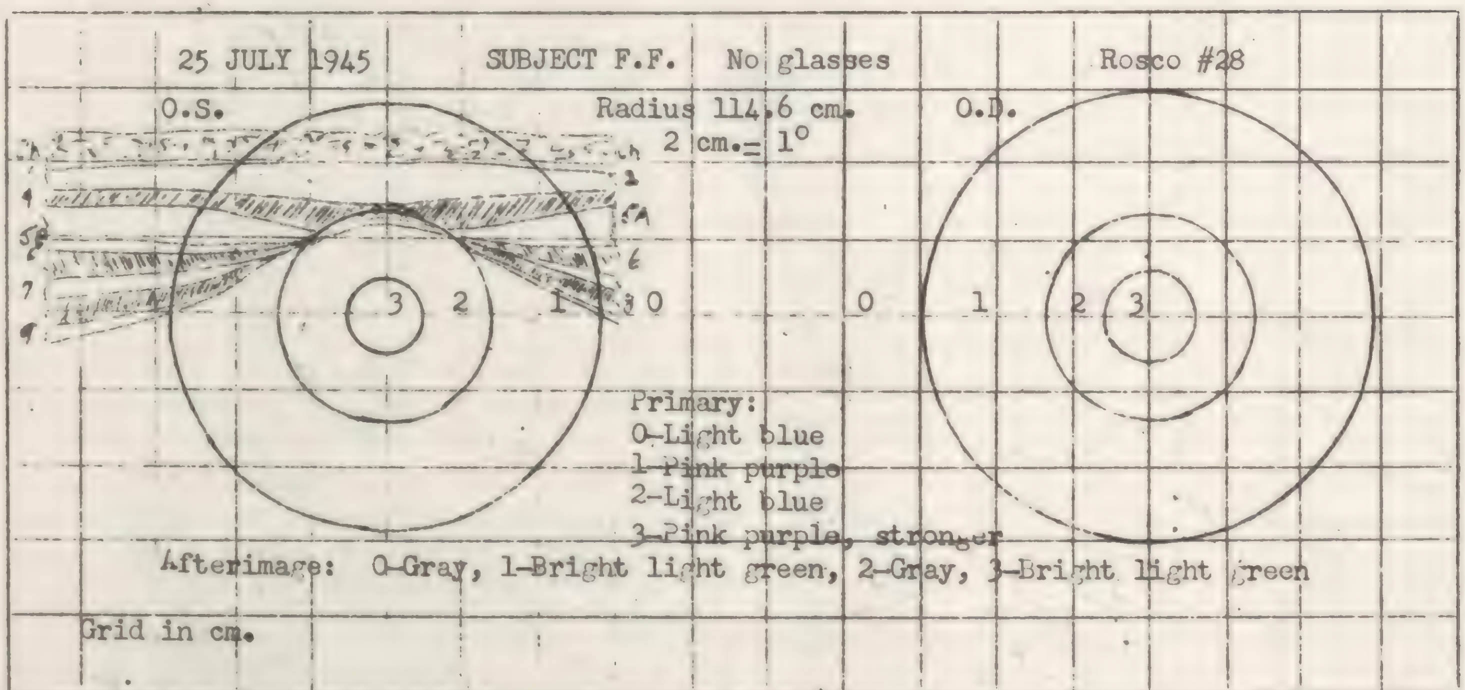
Of the 20 subjects, 19 were able to see with each eye a macular picture projected as an entoptic experience. The single subject that must be counted as a failure reported seeing a very small spot right at the first, but before this could be plotted it had disappeared, and repeated alternations of the filters and trials with several other pairs of filters failed to give positive results. This subject, tested about two weeks later, was again unable to see a macular figure.

Results for macular plotting

The usual macular picture which the observer, under the conditions outlined, sees surrounding his fixation point resembles the center portion of a circular target chart. At the very center is a small round spot or disc of homogeneous quality with fairly sharp, smooth boundaries. The disc is surrounded by a ring or band that has an overall diameter about three times as large. The ring is brighter than the central spot, has less color, or may appear of the same chromatic quality as the visual field outside the total macular picture. The outer circumference or boundary of the ring is fairly clearly marked and even. Outside the first ring is a second and broader ring or band of the same color as the central spot but more or less saturated. The over-all diameter of the second ring equals about $2\frac{1}{2}^{\circ}$ of visual angle. The outside circumference of this second ring is usually rather indistinct and fades into the visual field surrounding it. Sometimes the circumference of the second ring is described as smoothly round, sometimes as scalloped or resembling a "shell burst". Occasionally it is reported as quite irregular. A chart for subject F. F. is reproduced in Fig. 2. None of the 19 subjects used in this series reported a third ring or any distinguishable area differing from the background surrounding the larger ring. In plotting, the convention has been followed of numbering the circular areas from the outside to the center. The visual field surrounding the macular picture is designated as No. 0, the larger ring as No. 1, the smaller ring No. 2, the center spot No. 3. With the filters employed these areas are usually distinguishable in terms of color. On the chart for subject F. F., reproduced as Fig. 2, it will be noted that when viewing the macular picture through the purple filter the subject reported No. 0 as light blue, No. 1 as pink-purple, No. 2 light blue, No. 3 pink-purple, more intense. The afterimage, as seen through

FIGURE 2

Sample chart of macular plots showing the characteristic areas usually appearing in entoptic projection. The charts are depicted in the orientation in which they appeared on the screen. The dot at the center of each chart was supplied as a fixation point and is not a portion of the macular figure. A sketch of the human fovea in cross section adapted from Polyak has been placed in relation to the areas of the O.S. chart to indicate probable correspondences.



the neutral filter, was reported: No. 0 gray, No. 1 bright light green, No. 2 gray, No. 3 bright light green. The color reports for the two eyes are usually the same. A comment recorded with this chart reads, "Image often very poor after a few minutes of looking at screen." This comment points to the desirability of working with the eye in the rested condition and avoiding continuous staring at the bright screen.

Not all subjects see the central spot, No. 3, as distinguished from area No. 2. Of the 19 subjects who were able to see a macular picture only 14 could distinguish a plottable central spot for O.S., and only 12 for O.D. The average diameter for the 14 O.S. plots was 10.3 mm. with a range 7.5 to 14 mm. In terms of visual angle this equals an average diameter of 31' and a range of 22'-42'. In half of the 14 cases the central spot as plotted appeared to be round and in the other half, oval or eccentric. In only two of the oval pictures was the long axis clearly horizontal. The fixation point appeared to be central in 11 cases and clearly off center in 4 cases. No positive scotoma were reported. The color of the spot was usually reported as homogeneous purple or some variation of purple, such as red-purple, pink-purple, light purple, or magenta. The 12 cases for whom a central spot was plotted on the O.D. charts gave an average diameter of 11.0 mm. with a range of 9-14 mm. In terms of visual angle this equals an average of 33', range 27'-42'. In 5 cases the plot was round, in 7 cases oval; 4 of these showed the long axis horizontal. In 10 cases the fixation point was central, in 3 cases off center. In no chart was the fixation point so far off center as to fall outside or even near the boundary of area 3.

Area No. 2 was plotted in 14 of the O.S. charts. In 2 cases this area appeared homogeneous throughout, that is, did not show a central spot or area No. 3. The average outside diameter in these 14 charts was 22.9 mm., range 17-31 mm., equalling an average of 69' and a range from 51' to 93' of arc. In 5 of the 14 charts area No. 2 appears to be round, in 7 cases it was oval, 5 of these with the long axis horizontal. In 2 instances what has been recorded as area 2 appeared as a crescent with rather irregular borders partially encircling central area 3. The crescents were complementary to each other in each pair of charts, appearing on the right hand side of the O.S. chart and on the left hand side of the O.D. chart, that is, on the temporal sides of the fovea in both these cases. The color usually reported for area 2 was a fairly close match for the background field, that is, No. 0, but sometimes it was reported in the primary stimulation as light purple or violet. In the O.D. charts area 2 was present in 15 cases. The average diameter was 23.7 mm., range 16-35 mm., equalling a mean of 71', range 84'-105'. In 7 cases area 2 appeared to be round. In 5 instances it was oval with the long axis horizontal. There was one case who reported the boundaries of area 2 for both eyes as fuzzy laterally but quite sharp at the top and bottom.

The over-all macular picture, area 1 inclusive, which was visible in both eyes to 95 per cent of the subjects, was reported both as a primary stimulation and as an afterimage with no observable change in size between the primary and the afterimage views. Of the 19 O.S. charts 12 may be classified as round and 6 oval. Four of the latter showed the long axis vertical or oblique, 2 horizontal. In cases of oval charts or outlines, here as elsewhere in this study, the mean diameter has been taken for purposes of averaging. The average diameter of these 19 charts, measured to the outside border of area 1, was 52.4 mm., range 40–85 mm. In terms of visual angle these values equal an average of 2°37' and a range from 2°–4°15'. The 19 O.D. charts for area 1 show 8 round, 7 oval, with the long axis horizontal, and 4 oval with the long axis vertical or diagonal. The average outside diameter for these charts is 54.4 mm., range 41–86 mm., equally average of 2°43' and range of 2°3'–4°18'.

Discussion

If we combine the average results for O.S. and O.D. for respective areas reported in the macular figure, we find average diameters of 32' for No. 3, 70' for No. 2 and 160' for No. 1 area[12/] The three average values approximate a series in proportion, 32 : 70 : : 70 : 160. To fit exactly, the terminal value would be 153. The ratio of area No. 3 to No. 2 minus No. 3 is 1 : 3.8, and the ratio of No. 2, including No. 3 to No. 1, minus No. 2 plus No. 3, is 1 : 4.2. Visual acuity measured at the center of the fovea and thence along a radius from that point has been pictured as a sharp smooth decline with no indications of steps corresponding to the three zones or their borders observable in the macular picture. With a technique available for charting the maculae of each observer the application of visual stimuli may now be made more uniform and comparable. But it must remain for future experimentation to discover if and in what manner the boundaries of macular areas define zones of varying functional character.

These studies of macular plotting give us no detailed objective information on the minute correlation between the pigmented areas and the groupings of photoreceptors in or near the fovea. They do offer, however, circumstantial subjective evidence of importance when considered in connection with objective data that are available. The entoptic macular figure is certainly darker than the surrounding field when viewed through colored filters, thus indicating loss of light through absorption. The figure is brought out best, in terms of

12/ The average area No. 1 may be a little large due to case T. L., who showed diameters of 85 and 86 mm., while there were no values found for the other subjects as high as in the 70's but several in the low 40's. On the other hand, T. L. gave a relatively high average for area No. 3 with 13 mm., but could not distinguish an area No. 2.

brightness, by deep blue or violet-blue light for which the yellow pigment of the macula has shown maximal absorption. The macular picture is characteristically concentric and symmetrical around the fixation point. The boundaries must always be viewed without actually fixating them. In most instances the figure is observed to be made up of different areas or bands which are concentric with each other. In the plottings so far made never more than three concentric areas have been distinguished. Area No. 3 or No. 2, or both of them, may not be reported enclosed in area No. 1. Usually the figure seen with one eye is substantially the same as that seen with the other. Subjects retested after an interval of several days show quite similar charts. Viewed binocularly the macular figure appears more substantial and with more distinct boundaries than when seen with one eye alone, especially in untrained subjects. No subject had an off center fixation point displaced as far as the plotted border of his area No. 3. Two cases, not in this series of 20 subjects, reported small black spots (positive scotoma) near or at the center of area 3; both cases had eccentric fixation points but not outside this area.

What do these areas correspond to in terms of the fovea? Is it probable that they are so many different areas of the foveal pit itself? Perhaps it is not too early nor is this investigation too preliminary to warrant an attempt to answer these questions. Histological studies of the Macaque and of the human retina, as recently reviewed and reported by Polyak[13], show that the yellow pigment is most saturated along the slopes of the foveal pit including the margin of the foveal floor. The floor itself, in comparison with the slopes of the pit, is described as practically colorless in the Macaque where the floor is flat and also in man where the floor tends to be concave in contact with the vitreous. Peripheral to the external border of the foveal depression the amount of pigment found in the retinal tissues becomes gradually less, decreasing until it fades out at the temporal margin of the optic disc, and in other directions this very faint pigmentation may appear nearly as far as to the large blood vessels surrounding the central area. The known and characteristic distribution of the pigmentation in its various degrees of saturation thus seems to offer a parallel which agrees in part with the entoptic macular figure found in these experiments. Area No. 1 as plotted in our charts certainly does not correspond with the broad pigment distribution found in histological studies to surround the outer border of the foveal pit. While Area No. 1 has a fairly faint periphery, it fails to demonstrate the extent of gradual fading which the larger pigmented area would seem to require and is also much too small to represent that area. Area No. 1 most probably corresponds to the main slope of the foveal pit; reaching toward the upper margins where the depression begins and including the lower margin where it terminates in the floor of the pit.

13/ S. L. Polyak. The Retina. University of Chicago Press, Chicago, 1941. Pp. 607.

Polyak (see his Fig. 38 and page 198) gives the width of the entire foveal depression measured from edge to edge for man as 1500 μ corresponding, in terms of the conventional eye, to 5°. This is almost twice the angular diameter found as an average for area No. 1. The indications are that our plots of area No. 1 exclude the outer foveal border and a portion of the depression which may have less yellow coloring then the lower slopes. If the angular diameter derived from measurements on tissue specimens is to be accepted, then it would seem that area No. 1 does not fully encompass the rodless territory.

The entoptic findings appear to be in close agreement with tissue descriptions and measurements for the larger portion of the floor of the retinal pit. The floor is almost colorless or very slightly pigmented in comparison with the foveal slopes and measures 400 μ across or slightly more, which is taken to equal $1^{\circ}20'$. Area No. 2 in the macular figure is found to be colorless in the sense that it matches the field surrounding the entire figure or is faintly colored in the chroma of area No. 1, and it measures $1^{\circ}10'$ on the average for the cases studied.

The case for area No. 3 is not so clear. The floor of the retinal pit contains a depression termed the foveola, at or near the center of which is a still deeper area called the umbo or navel (see Polyak, page 198). The diameter given for the foveola, 350 μ, would equal 78', which is too large to fit area No. 3. Presumably the umbo, which is a fovea within the fovea, corresponds with the point of fixation and will be found in register with area No. 3, contained or partly contained within it. At present, data on the diameter of the umbo seem to be lacking. Polyak points out that extensive data are not yet available on the precise form of the foveal fundus in man. Area No. 3 corresponds in brightness and color with area No. 1. Some of the difference in brightness and color between area No. 2 compared with areas No. 1 and No. 3 is probably due to contrast enhancing the differences but not basically accounting for them. Light absorption by the yellow pigment would appear to be a basic reason for entoptic results found. But so far as the writer has been able to learn, it has not been reported that the umbo shows a concentration of yellow pigment comparable to that in the great slopes of the pit. Conceivably, this may be found to be the case. On the other hand, it seems more plausible to apply Walls'[14] data and arguments and assign the darkening of this area to the refraction effect of a sharper slope than is present in the foveola generally and which operates as a magnification device distributing the light over a larger area and thus somewhat decreasing its apparent intensity. Pigment and the sloping surfaces of the fovea thus operate in the same direction in darkening the macular figure. Further pursuit of an attempted parallel between the histological and entoptical

14/ G. L. Walls. The Vertebrate Eye and Its Adaptive Radiation. Cranbrook Institute of Science, Bloomfield Hills, Mich., 1942. Pp. xiv-785.

results is probably not warranted at present. However, on the basis of the entoptic results we may predict that further histological findings will show a small island of fairly saturated yellow pigment at the center of the foveola, or that the feature called the umbo is a fairly sharp V-shaped depression, or that functionally the photoreceptors at this region possess a significant decrement in their relative responsiveness to light along with their peculiar mandate for dominating visual fixation.

In conclusion, the results of this study indicate that entoptical macular plotting offers promise as a visual measure as a supplement to field perimetry. It can be carried out rather simply on most cooperative human subjects. It provides a technique for detailed study of the fovea that is functionally direct and comprehensive. It takes the subject into full confidence and thus stimulates the interest of the person who is examined. It may serve to advance knowledge and practice in a variety of problems otherwise difficult of approach. Its uses and limitations, especially in pathological conditions, largely remain to be explored.

<u>Discussion:</u>

Dr. Peckham asked if correlations would be made between Dr. Miles' results and the results of scotopic perimetry. Dr. Miles stated that such correlations would be made in cooperation with Lt. Comdr. Sulzman.

Dr. Tousey reported similar entoptic observations made in looking at the ceiling without filters.

Dr. Berens asked if the avascular area can be plotted by this method. Dr. Miles thought that the avascular area is larger than the area demonstrated by his method, but Dr. Berens expressed the opinion that it is just a little smaller, less than $2\frac{1}{2}^{\circ}$.

Dr. Scobee pointed out the value of this method in demonstrating early lesions of the fovea before fungus could be detected. The area is so small, however, that if a parafoveal lesion were $2\frac{1}{2}^{\circ}$ away from the fovea it could not be demonstrated.

Lt. Farnsworth stated that Dr. Miles's method might be important in determining the effect of macular pigmentation on the perception of color seen at small subtense, for example, for signal lights and color coding. Color is usually selected as though it were to be seen at large subtense; color seen at small subtense changes radically.

3. DEVELOPMENTS IN NAVAL CAMOUFLAGE

Comdr. D. R. E. Brown

There have been few developments in Naval Camouflage in the past four years. I believe the progress has been in the application of visibility laws and in applying principles of concealment design long known by a few, neglected by the Navy as a whole, and often opposed by that great majority of people who have eyes but see not. The job has been one of selling through demonstration even more than by research and development. There are a few exceptions.

Naval aircraft camouflage, camouflage of surface ships, of landing craft, of submarines, and of ground emplacements can all be summed up briefly.

The various tactical situations were put down in order of expected importance. Naval aviators without exception were most concerned with concealment from enemy eyes above them. Next from enemy eyes below them. In both cases over water. The obvious result was a design which was a dark shade on top, and white below. I say obvious. It was obvious to a few. It took a lot of demonstrating to convince the Bureau of Aeronautics that white on the shady side of a wing was a better match to the blue sky above than a sky blue paint. Eventually white won out. It also required a regular sales campaign to show them that a paint of very dark tone, nearly black, and having some gloss, was better for topside of wings than a "nonspecular" paint of a lighter shade. The dark, "semi-glossy" paint won out. Incorporating semi-gloss paint in the aircraft camouflage design may be considered a development, for a considerable amount of new work was necessary. By cut and try and measure we arrived at a shade and gloss which, when under direct sunlight, would appear as dark as deep sea water directly below and when seen from other angles would appear to increase in brightness just as the sea would become increasingly bright when viewed from more oblique angles, especially over a calm sea.

Later the tactical situation changed from defense to offense in the air and speed became more important than concealment. Also production of aircraft became more important than any concealment at all from the enemy. The result of all this was that high gloss for speed-in-flight and one shade of paint for speed-on-the-production-line were adopted. The dark tone, still most essential for concealment from above was retained. Black was obviously the best shade for night, where searchlights were the principal detectors. That required little selling. Obvious to some of us, white was the hardest thing to see against the sky at night when artificial lights were not present. That took more selling, but white was finally adopted for some of the planes. Just what ones I can't say because by that time I had left the Fleet Aircraft Tactical Unit and my work with the Bureau of Aeronautics and gone over to work with Ships.

Surface ship camouflage design had already been well developed in World War I. It had been found that the concealment of large ships was more difficult, even under low levels of illumination, than deception. Also that deception, as to course, type and speed was a better weapon against submarines than partial concealment. Hence, the deception patterns. Most people look upon these as hit or miss razzle-dazzle splotches; but actually they are patterns carefully designed to falsify structure and perspective in such a way that ships on one course appear to be on another. Almost all of the patterns that falsified course automatically retarded, and in some cases made impossible, ship identification as to type.

The first concern of our surface ships in the early phases of the war was enemy aircraft. Hence, ships were simply painted dark blue. The next phase called for course and type deception patterns against enemy submarines, which were always considered a great potential enemy. However, low visibility was always held of great importance to many and of first importance to some. But only a few could agree on the time and place it would be most needed; none on how it should be achieved.

All of the pattern designs were divided into three classes: (a) patterns of strong contrast which were most effective for course and type deception, but which were never in the lowest visibility group, (b) patterns of moderate contrast which resolved to a relatively <u>light</u> toned silhouette with distance and were least visible against a sky background and hence invisible under some night conditions, (c) patterns of moderate contrast which resolved to a relatively <u>dark</u> toned silhouette with distance and were less visible against the sea or shore background and hence invisible under some night conditions. Unfortunately, the tactical conditions could not be predicted far enough in advance to permit selection and application of the appropriate degree of contrast with any degree of efficiency. The fact that our ships had pretty close to the proper painting for each of the various phases of the war, was more a matter of luck and lucky blundering than strategic planning. The unfortunate exception was the lack of deception patterns in the Atlantic when U-boats were taking a toll of American lives far greater than was, perhaps, necessary.

Later, when enemy aircraft and shore batteries came to the fore, and the threat of enemy submarines was more than proportionally reduced, the deception patterns were replaced in many cases by simply painting the ships dark again. Conspicuity and disfigurement were the principal objections to patterns. It is of interest to note that conspicuity was confused with highly visible. Many wrongly assumed that if a ship was conspicuous at a short range, it was a foregone conclusion that it could be seen farther than a less conspicuous one. Considerable effort was given to correcting this misunderstanding, but I'm sure the confusion still exists in the minds of many.

For small boats, landing craft and submarines, concealment was always considered paramount. The questions again were "Where, when, and from what direction was concealment most needed?" These questions had to be answered by high ranking officers who knew strategy and tactics. Admiral Turner saw early in the game that concealment for his landing craft was highly desirable and he himself designed an interim measure which was more effective than the plain blues in use at that time. In December, 1942, he requested camouflage officers to make a firsthand observation of the Solomon Islands and other islands and atolls in the South, Southwest and Central Pacific, from land, sea and air. As a result of this survey, we were able to design a pattern for landing craft which, though difficult to apply, was very effective for concealment against a wide variety of backgrounds.

The war moved too rapidly in the Pacific to do much with ground installations, nor did the type of open sea warfare and short term land invasions call for much concealment of ground installations. As far as I know, no new developments were made either by Army or Navy along these lines. Very elaborate and costly installations were made by both Army and Navy in all parts of the United States and the Hawaiian Islands. Certainly there was no need for new developments.

Our submarines at the beginning of the war were painted black, which is as good and practical a shade as any for horizontal surfaces which face upward. Black gave ample concealment from aerial observation while the submarines were at periscope depth in water that was deep and not too calm. Like most people, though, the "Submariners" thought that black was the safest shade at night, regardless of where and how it was viewed. They felt more secure on the surface than was warranted. Again it took a series of demonstrations to show that even white can appear dark and that if submarines were going to operate on the surface at night, where they could maneuver with greater ease and much greater speed, black was not the best shade for a one-all-over paint job. Two gray designs were developed and adopted; one for general use including night surface attacks, and the other for special reconnaissance patrols in certain restricted areas. Each is an elaborate design, requiring a good deal of supervision in application. Many shades of gray from so-called black to white are used in an effort to arrive at a soft, simple looking tone. Because of the limited number of submarines, great care was put on the individual painting of each. Special paints were made just for submarines; detailed specifications were issued and paint crews instructed at every submarine base and submarine tender from New London to Western Australia. But the effort was worthwhile. More enemy shipping was sunk. Submarines got closer to the enemy unsighted. "Submariners" gained even greater and more warranted confidence.

No new principle had been propounded; just the explanation and demonstration of the principles of visibility and of concealment design--principles as old as fish. The follow-through to the painting

was important. "Submariners" became interested in the principles of visibility and concealment and learned a lot about its advantages and limitations as applied to their own ships.

Application of concealment principles, which we might say are principles of visibility used in reverse, has, however, demonstrated that other people should be given some instruction. Safety demands a better understanding of what we see, why we see it, and how far we can see any given thing under any given condition. What are the factors at sea, and in flight, that have the greatest appreciable influence on the four fundamental variables of visibility? How much do they affect them?

Our work in concealment has taught us that although considerable progress has been made in recent years in the science of visibility, there still remains a great need for further research in this field. Neither the Navy nor the Weather Bureau has, as yet, the information it needs for visibility forecasting or for getting the most out of seeing when it comes to search and rescue, use of optical instruments, or the thousand and one common tasks for which we should know how to use our eyes, but don't!

I believe it is important that practical questions be kept before those conducting a research. It is important that reports of investigations in the field of visibility be put into a form that the layman can understand.

I have observed that the rate of progress of some investigations has been accelerated by a person interested in the application of the result, as well as by the ability of the scientist making the investigation. I'm curious to know how the investigations now under way are coming out, anxious to see the constructive uses to which a new and broader understanding of seeing will be put.

But I am not satisfied that the many agencies now investigating vision and visibility are sufficiently organized for coordinated effort. There is no national or international body for standardizing even the terms and measures used in visibility research. There is today no national organization set up with authority and financial backing that can direct a broad investigation into the factors of seeing, upon which, to a certain degree, the public safety will always depend. Nor is there a central clearing house for the distribution of what is already known. There should be, there must be, a course of instruction in qualitative and quantitative seeing available to every man who drives a car, every railroad engineer and fireman, as well as to aviators and men of the sea. I believe we should start by teaching simply the limited facts that are known now to pitiably few: elementary principles of contrast, color, form, reflectance, and so on. Then it is up to you, to those of you who are trained and qualified, to pursue these subjects further. Establish for us standard terms and measures. You will probably have to agree on standard instruments and procedures for

investigating, too. There will have to be groups established for collecting data and other groups for classifying and integrating it. You will have to include not only men with knowledge of the physiology and psychology of the human seeing machine, but also physicists trained in optics and who can analyze the micro-physical properties of the atmosphere through which we see; photometrists to measure the brightness contrasts; meteorologists familiar with the lower levels of the atmosphere; and aerologists who can study the upper air.

Discussion:

At the conclusion of his paper Comdr. Brown proposed that the Vision Committee petition the Congress, through the proper channels, to establish and finance a Federal agency to conduct a program of vision and visibility research.

Comdr. Peckham stated that there is a need to use civilian scientists already at work and that it is not necessary to petition for special funds. The continuance of the Vision Committee would ensure that research would be recommended and that qualified personnel would be employed for carrying it out. Others agreed that one of the responsibilities of the Vision Committee in the future would be cognizance of available financial support for vision research. The Secretary pointed out that Congress has not yet passed legislation for a national research foundation, and suggested that the motion proposed by Comdr. Brown be tabled.

Comdr. Brown agreed to table the motion, and suggested that, since the Vision Committee is not a research agency, but a clearing house for research, a substitute resolution, recommending that a correlated, integrated, and properly financed research program in vision and visibility be undertaken, would be in order. Several members agreed that funds for research will be available, and active encouragement and financial support for visual research are necessary.

The following substitute motion, formulated by Comdr. Dyke, was adopted unanimously:

> "The Army-Navy-OSRD Vision Committee will consider it one of its primary duties to determine visual problems on which research is needed and to foster the devotion of adequate funds, facilities, and personnel to research for the solution of those problems."

4. PROBLEMS IN THE DESIGN OF RANGEFINDER RETICLES

Dr. C. H. Graham

The following report of work done under Contract OEMsr-1059, Division 7, NDRC, was originally presented at the Joint Army-Navy-OSRD Conference on Psychological Problems in Military Training, 15-16 August 1945.

Introduction

It would be impossible, within the time limits available for my report, to give a full discussion of all of the factors in reticle design which determine the stereoscopic performance of rangefinder personnel. For this reason I shall restrict myself to consideration of two important aspects of the topic.

Performance as a function of height of image adjustment

The variability of observer performance is greatly affected by a condition known as "height break." Height break occurs when the positions of the target images for the left and right eye vary in elevation with respect to the reticle. In the operating situation it occurs when improper height of image adjustments are made.

An example of height break is shown in Figure 1. In this figure the reticle is a circle. The observer regards the reticles in Figure 1A, and under proper conditions of instrument adjustment, the two circles are fused if the target for the left eye is in the same position relative to the reticle as the target for the right eye. In Figure 1A this latter condition is not encountered. The target for the right eye is, relative to the reticle, lower than the target for the left eye.

Figure 1B gives a diagram representing a projection on a hypothetical "fusion center" (within the observer) of the target and reticle combination of Figure 1A. The target is represented as fused, a condition holding under usual circumstances. The reticle is single but appears in a distorted manner.

A conceptualized view of what the observer sees as he looks at the two fields of view in the rangefinder is given in Figure 1C, where it is supposed that a hypothetical observer is regarding, from the side, the hypothetical visual objects which the stereoscopic observer regards through the rangefinder eyepieces. The objects as seen from the conceptual viewpoint consist of a target, localized in space, and a circular reticle twisted out of shape in such a manner that the highest and lowest points of the circle seem nearer to the stereoscopic observer, the middle part being farther away. The amount of distortion is not a small matter, for it can be shown that, relative to the size of the plane, it is considerably larger than is indicated in the diagram. Obviously,

when a reticle shows such an appearance, it is impossible for an observer to range on a target, for the observer does not know which part of the reticle to use for reference. In other words, great inaccuracies may come about due to a condition of height break. In extreme circumstances, ranging is impossible.

Consider some theoretical aspects of the distortion. Figure 1B indicates that, when the target images are fused, the reticles for the two eyes provide conditions of retinal disparity, as indicated by the symbol d. Points on the reticle for the right eye fuse with horizontally aligned points for the left eye, but because the disparity, d, varies as a function of the condition of "height break," horizontally aligned points for the two reticles have different disparities, and hence points on the fused reticle appear at different ranges.

The circle demonstrates height break effects in an extremely striking manner. However, it may be shown that deleterious effects due to height break occur whenever curved or slanting lines are used. Figure 2 indicates results which have been obtained with a great number of reticles and under various conditions of height break. It will be seen that some of the reticles give a very great increase in variability of performance as "height break" increases, whereas others do not. In particular, it should be noted that the Navy diamond reticle is poor in this regard, whereas a reticle which presents simple vertical lines, as in Figure 3, shows very little change in precision of performance as height break increases.

The reticle of Figure 3, a vertical line reticle with fore and aft marks, is extremely resistant to height break and is one which has been recommended to the Navy.

<u>False fusion</u>

Another interesting group of psychological effects centers about the problem of "false fusion."

Figure 4 represents the effect. Figure 4A shows a view of the field for the left eye and for the right eye. (Numbers above the reticle marks are presented for ease in identification. They are, of course, not present in the reticles themselves.)

When the right and left eye views of Figure 4A are fused properly, the observer sees the view of Figure 4B; a view consisting of three fused lines hanging in space, where lines 1 and 4, 2 and 5, and 3 and 6 are fused. However, it is possible for an anomalous condition of fusion to occur where line 1 is unfused with any line of the right eye reticle; line 2 is fused with line 4; line 3 is fused with line 5; and line 6 is unfused. The unfused lines take up the spatial position dictated by the fused lines, and the whole configuration appears in the space assigned by the fused lines. The lines of sight to the reticle under the latter conditions are more divergent than is the case under

proper fusion conditions. For this reason, the reticle seems farther away to the observer than it does when proper fusion occurs. At any rate, the net result of "false fusion" is to make it possible for the observer to establish contact between the target and the reticle at more than one setting of the range scale, i.e., for a position of true or false fusion. How many of such settings can be made, and whether or not they can be made, depends upon the geometry of the reticle design.

A simple preventive of false fusion consists in placing fore and aft marks in the reticle. The provision of fore and aft marks makes it impossible for incorrect fusion to take place without a perceived doubling of the fore and aft marks. Because of the fact that fore and aft marks have been judged to be useful in "spotting" as well as in preventing false fusion, they are valuable additions to the principal reticle configuration. In addition, we have shown experimentally that fore and aft marks do not decrease resistance to height break.

Other devices may be used for guarding against false fusion, but time does not permit their full consideration.

Other factors in reticle design

It would be possible to speak of a number of factors in reticle design other than those enumerated. Particularly in the case of illuminated reticles (i.e., reticles in which the lines are brighter than the background), it would be important to consider the problem of optimum reticle illumination. These and many other questions make the topic of reticle design an important practical problem for both the instrument maker and the psychologist.

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5. DESIGN AND TESTS OF RIFLE SIGHTS

A. PROBLEMS IN THE DESIGN OF RIFLE SIGHTS

Digest of discussion by Comdr. Dyke:

I. Form of rifle sights

The form of sights for small arms has changed very little through the centuries. Two forms are most common for front sights: A rear sight is usually one of the following forms: Various combinations of these forms have been used. The basic question is: Does the problem of the form of rifle sights warrant further investigation?

II. Position of front and rear sights

The position of the sights varies with the instrument. A greater distance between sights gives greater accuracy of alignment of the two sights. However, since the eye has to focus on two sights and the target, there is an advantage in having the rear sight in a forward position to give greater separation between the eye and the rear sight. Quantitative data are needed to determine the optimum position for front and rear sights.

III. Placement of sights in relation to target

The standard doctrine for sighting states that the sights should be aligned tangent to the target. Some expert marksmen aim at the center of the target. Data are needed to determine the best method for lining the sights on the target.

B. COMMENTS ON TECHNICAL REQUIREMENTS FOR RIFLE SIGHTS IN ARMY ORDNANCE

Digest of discussion by Mr. Darr:

The general problem in the use of rifles in the Army is one of snap shooting rather than long-range or deliberate shooting. For the latter it has been found that a $2\frac{1}{2}$X sniper's telescope mounted securely on the rifle is desirable. Allowance for deflection and range can be incorporated in the telescope by the use of a moving reticle.

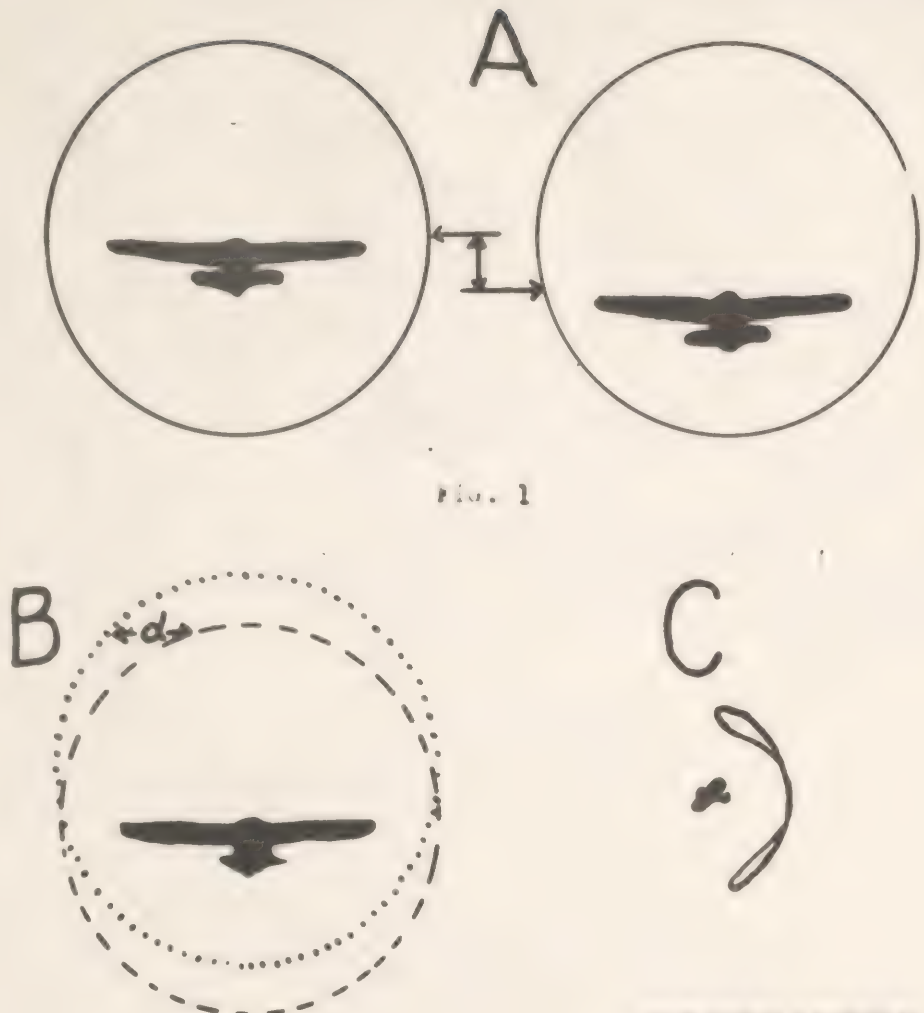


Fig. 1

A: An example of height break for a circle reticle. The position of the target is higher in the left eye than in the right eye.

B: The condition of fusion holding for the reticles when the target is properly fused. The dotted circle represents the circle reticle for the right eye; the dashed circle, the reticle for the left eye. d is resulting disparity.

C: Conceptual appearance of B, as projected in space and seen from the side of the reticle and target.

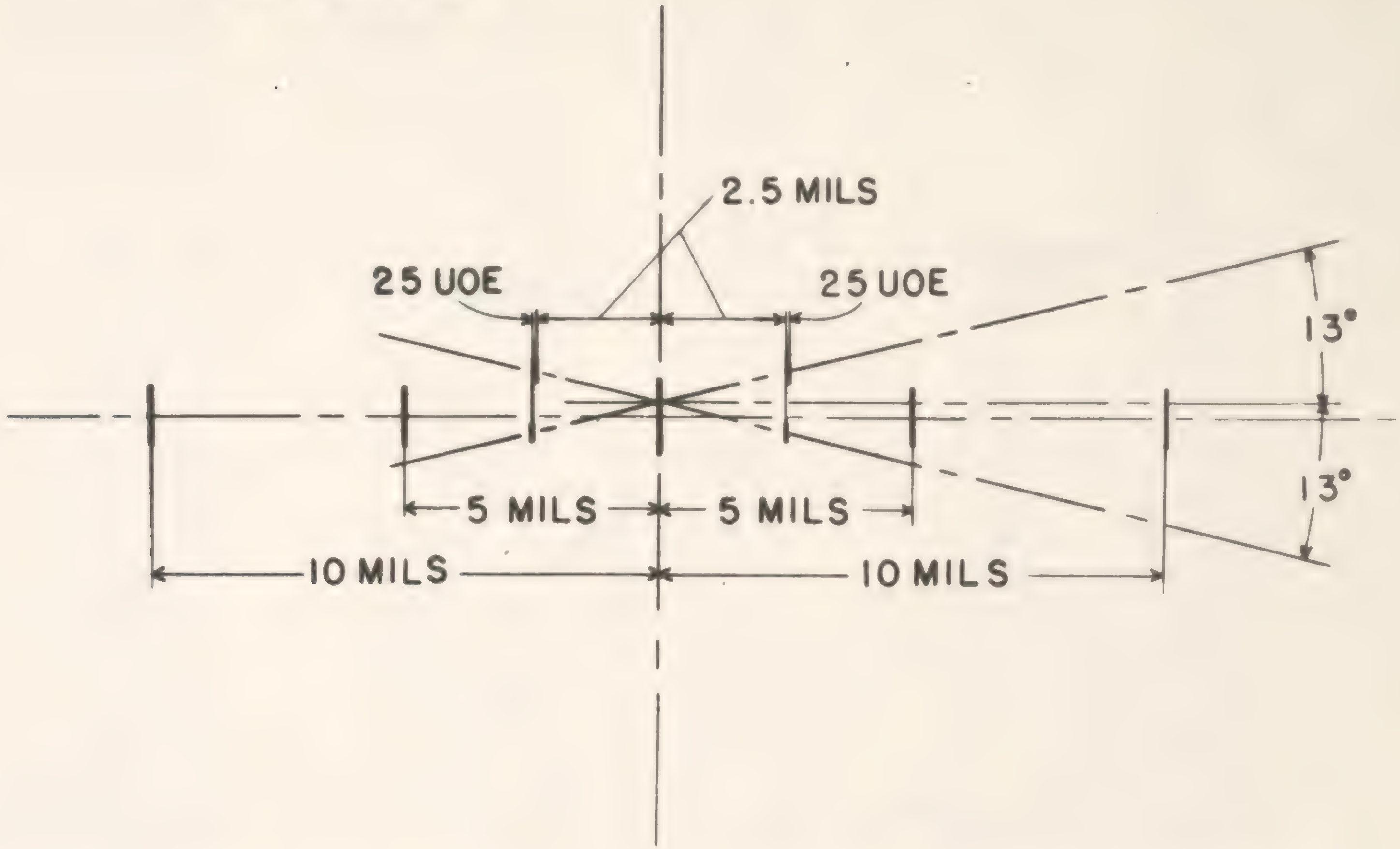
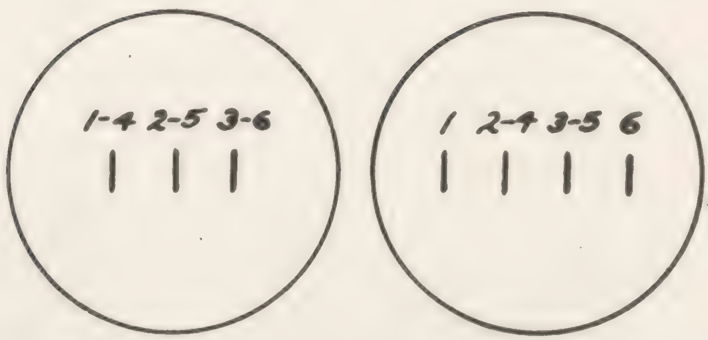


FIGURE 3. Drawing shows positions of fiducial marks in left field (with fore and aft marks seen as at 24 power). Right field appears as a reverted image of left field. The fore and aft lines are inclined 13° toward the horizontal axis and intersect on the vertical center line at a point 1.00' above center line of reticle. All mil measures are in terms of true field.

The fore and aft marks are offset 25 UOE from the central measuring mark. Fore marks appear in the upper field, and aft marks, in the lower field.

MONOCULAR VISION

FIG. 4 RESTRICTED



CORRECT FUSION FALSE FUSION

BINOCULAR VISION

Figures Above Fiducial Lines Not Present In

Real Reticles. Used Here For Line Identification.

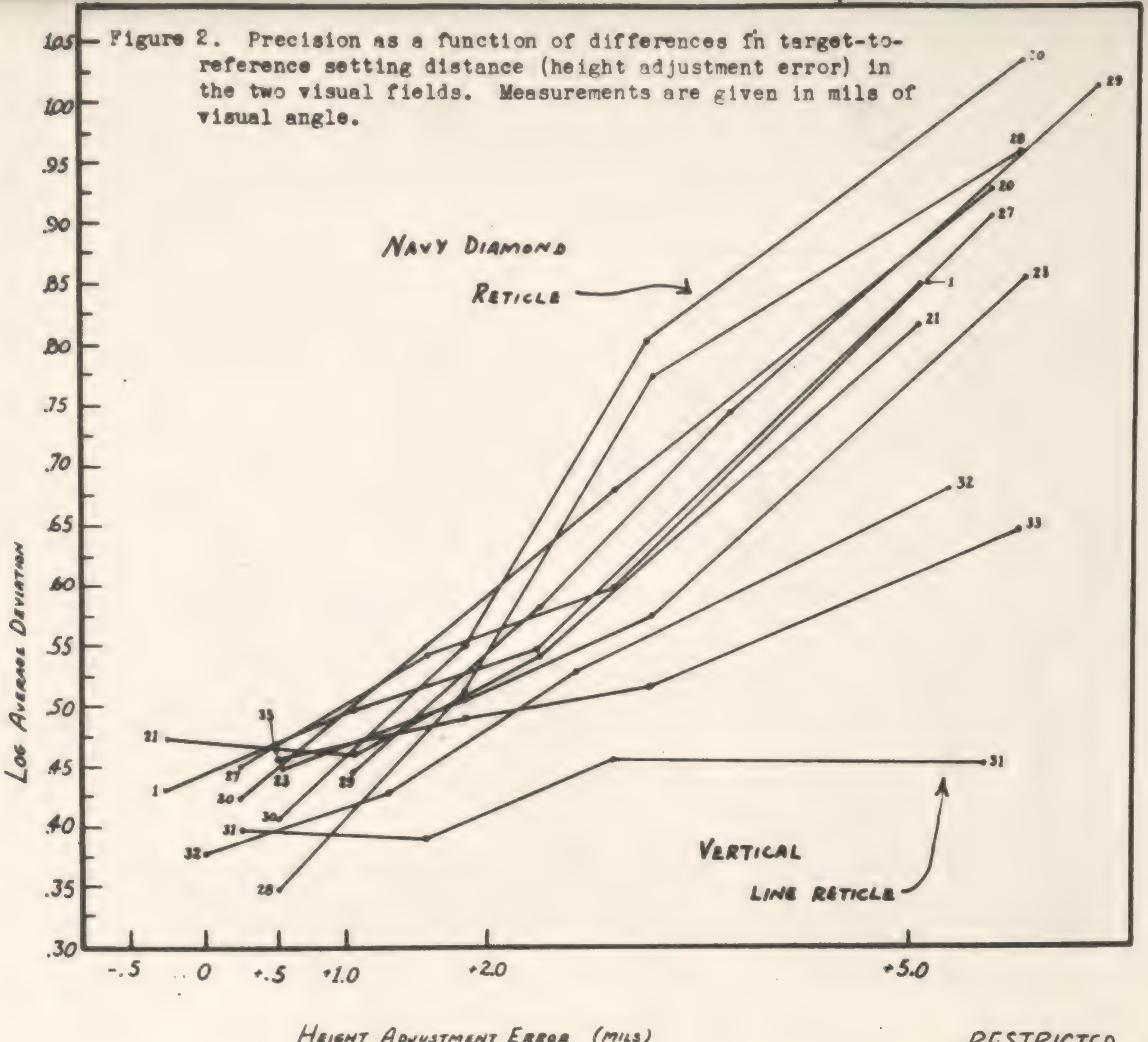


Figure 2. Precision as a function of differences in target-to-reference setting distance (height adjustment error) in the two visual fields. Measurements are given in mils of visual angle.

Discussion:

General discussion of problems in the design and tests of rifle sights followed the final presentation by Dr. Warden. (See Confidential Supplement.)

Lt. Col. Noble asked if reflex sights can be used with rifles. Mr. Darr explained that several such devices employing sky, battery, or radium illumination, and one interference type, are now under consideration.

Major Roberts suggested that basic data are needed on the question of whether a man should use one or both eyes in shooting a gun. Dr. Burger thought that men with dominant right eyes seem to be able to use both eyes effectively. Those with dominant left eyes tend to close the left eye when sighting with the right eye.

Capt. Sparks suggested that data on this problem would have to be obtained using untrained observers to avoid habitual techniques of experienced marksmen.

Comdr. Dyke proposed that tests be made of a rifle having both a telescopic sight and notched sights for all-purpose shooting.

6. REPORT OF THE SUBCOMMITTEE ON PROCEDURES AND STANDARDS FOR VISUAL EXAMINATIONS

The following report was presented by Dr. Marquis, acting for Dr. Vail, Chairman of the subcommittee.

The third meeting of the Subcommittee was held on 24 July 1945 at the National Academy of Sciences, Washington, D. C. The following were present:

Members of the Subcommittee:
- Col. Derrick T. Vail, Chairman
- Dr. Walter R. Miles
- Lt. Col. P. R. McDonald
- Lt. Comdr. R. H. Peckham
- Capt. R. G. Scobee
- Dr. Donald G. Marquis, Secretary

Guests:
- Capt. C. W. Shilling
- Lt. Comdr. B. J. Wolpaw
- Lt. J. H. Sulzman
- Lt. Earl Green

<u>Manual - Testing Visual Acuity</u>. Copies of the revised manual were distributed to the Subcommittee members, and it was agreed that it should be presented to the Surgeon General, U.S. Army, the Air Surgeon, AAF, and the Chief, Bureau of Medicine and Surgery, for distribution to field installations for trial and comment. It was further agreed that after comments had been received, the Subcommittee should meet to consider revisions and attempt to secure agreement among the Services.

<u>Acuity test charts</u>. The present stage of development of new test charts was outlined and discussed. The new Bausch and Lomb illuminated testing cabinet was displayed and examined. In view of the desirability of reducing extreme contrasts in the field of view of the examinee, the Subcommittee voted to recommend that the cabinet be painted white (crinkle or matte-finish).

<u>Testing phoria</u>. Reports of completed and current research on the measurement of phoria were presented by Capt. Scobee, Lt. Sulzman and Comdr. Wolpaw. Their papers are appended to this report. After discussion it was agreed that a manual for the testing of phoria could be prepared on the basis of present knowledge, and the Subcommittee voted to ask Capt. Scobee to prepare such a manual which would be circulated to the members for comment, and revised at the next Subcommittee meeting.

Committee status. After discussion of the multiplicity of problems in the field of vision testing and the long-range nature of the work, it was agreed to recommend that a Subcommittee on Procedures and Standards for the Visual Examination be continued beyond the present war emergency, and that this Subcommittee be requested to formulate and supervise the conduct of research in the general field of visual examination.

It was agreed to recommend the appointment to the Subcommittee of Dr. Conrad Berens and Lt. Henry Imus, USNR.

The fourth meeting of the Subcommittee was held in the morning and evening of 11 September 1945, at the U.S. Submarine Base, New London, Conn. The following were present:

Members of the Subcommittee:
- Dr. Walter Miles
- Dr. Conrad Berens
- Lt. Col. P. R. McDonald
- Comdr. R. H. Peckham
- Major Trygue Gundersen
- Capt. R. G. Scobee
- Lt. Dean Farnsworth
- Lt. Henry Imus
- Dr. Donald G. Marquis, Acting Chairman and Secretary

Guests:
- Capt. C. W. Shilling
- Dr. Franklyn Burger
- Dr. E. O. Hulburt
- Dr. C. W. Bray
- Dr. R. Tousey
- Col. Merrill J. Reeh
- Lt. Col. J. L. Matthews
- Lt. Comdr. J. H. Sulzman
- Capt. Henry Pfingst
- Capt. C. P. Sparks
- Lt. E. L. Green

In the absence of Dr. Vail, the Secretary, Donald Marquis, was asked to act as Chairman and to prepare the report to the Vision Committee.

Manual - Testing Visual Acuity. Comments on the manual from Army and Navy installations which had examined and tried it during the past month were read to the Subcommittee. Discussion led to agreement

on three minor revisions, and Lt. Farnsworth and Lt. Imus were asked to formulate them for inclusion in the Manual. It was agreed that the Manual should now be turned over to the Services for their use. (Copies of this final revision may be obtained by request to the Executive Secretary.)

Acuity test charts. Four new acuity test charts have been developed by Comdr. Peckham, Lt. Farnsworth and Capt. Scobee, and preliminary determinations of standardization and reliability have been carried out. The Subcommittee recommends that these charts next be standardized and compared with present acuity tests in a large scale field research. Lt. Col. McDonald has consented to initiate a request through channels for such a project to be carried out by the Personnel Research Section, Adjutant General's Department. If such a project is authorized, the Chairman was instructed to designate a small working group to advise with AGD in planning the research and analysing the data.

Manual - Testing Phoria. The draft of the manual prepared by Capt. Scobee had been circulated to the Subcommittee prior to the meeting. It was agreed that the manual should be forwarded to the Army and Navy for distribution to field stations for trial and comment. (Copies may be obtained by request to the Executive Secretary.)

A. TESTING VERGENCE AND PHORIA

Capt. R. G. Scobee

The eyes are universally admitted to be the most important of the organs involved in flying. It follows that the aviation sections of the armed forces should be concerned with the battery of tests of the eyes used in the selection of flying personnel. Because relatively few of the examiners have any ophthalmologic background, it seems essential to select the simplest tests which will still be accurate. Simplicity of testing techniques make for easier, more efficient teaching and, what is more important, for wider standardization of the tests in question.

1. POWER OF CONVERGENCE. At present, a determination of the convergence near point is required. In AAF School of Aviation Medicine Project 139, Report 1 (2 November 1944), it was pointed out that this determination is loaded with inaccuracies. It is a measurement which can be quickly and markedly improved with practice, in most cases. Since convergence is controlled by two cortical centers, one frontal and the other occipital, the vast majority of examinees can be taught to utilize their frontal (voluntary) center for convergence in a very

short period of time. A man can quickly learn the 'trick' of voluntary convergence but this in no way signifies that his ability to perform sustained close work has been enhanced. Determination of the convergence near point should be eliminated entirely from the examination. This means that, with the exception of a few cases (see section 2), determinations of the interpupillary distance could also be eliminated.

2. POWER OF CONVERGENCE, EMPLOYING THE ROTARY PRISM. A test of prism divergence is used at a testing distance of 20 feet. AAF School of Aviation Medicine Project 139, Report 1 (2 November 1944) points out the reasons for testing prism divergence at 13 inches, suggesting a minimum requirement of 15 prism diopters at this distance. In doubtful cases, when the actual prism divergence is smaller than the theoretical prism divergence (calculated on the basis of interpupillary distance) the difference between the two should not exceed 6 prism diopters. A table of calculations was given.

There is a requirement that "divergence must equal or exceed any existing esophoria." The source of this particular idea has been sought in vain in ophthalmic literature. It implies that any heterophoria should be matched by an equal or greater amount of vergence in an opposite direction. At a testing distance of 20 feet, this requirement has no apparent logical basis.

Perhaps the idea of "balance" in the term "muscle balance" may have been the source of this requirement. Consideration will reveal that any test of heterophoria depends for its integrity upon the <u>disruption of fusion</u>. On the other hand, any test of vergence is a <u>test of fusion and of nothing else</u>. This requirement implies that a balance should exist between two tests whose basic principles are diametrically opposed.

When using binocular single vision at infinity (20 feet or farther) the eyes never diverge but always converge. Even when looking at a distant star, a minimum amount of convergence is present. Never in the course of human existence is there any call for the visual axes of the two eyes actually to become divergent in relation to each other. In shifting the eyes from the reading distance to infinity, the degree of convergence decreases (negative convergence) and this might be considered divergence and will be mentioned later. A test of prism divergence at 20 feet calls for divergence that is never exercised. In short, prism divergence testing at 20 feet is a test of a function that is <u>never used</u>.

At a testing distance of 20 feet, there are allowed 10 prism diopters of esophoria, 5 prism diopters of exophoria, and 1 prism diopter of hyperphoria. The work of numerous investigators is in agreement in revealing that the normal examinee has an average prism divergence of 6 diopters at 20 feet. What point is there in "allowing"

10 prism diopters of esophoria if no normal individual has, on the average, more than 6 prism diopters of divergence "to match it?" Why not make the limit 6 prism diopters of esophoria? The answer is that, if divergence is left out of consideration, individuals with no more than 10 prism diopters of esophoria make perfectly satisfactory pilots, all other things being equal; this is based on an analysis of 200 cases (all flying personnel) studied at the AAF School of Aviation Medicine. The Air Service Medical (1919, p. 283) is in agreement.

There are some who might defend the requirement of prism divergence equal to or greater than any esophoria with the concept that for the comfortable performance of a physiologic function, at least 50% of the motive power producing that function be kept in reserve. The very fact that an individual with 10 prism diopters of esophoria at 20 feet can attain binocular single vision at all indicates that he is exerting 10 prism diopters of divergence (negative convergence) to do so. To require an additional 10 prism diopters of divergence, or 20 prism diopters in all, <u>might</u> be thought to be an application of the "50% in reserve" concept. That this is not the case is revealed when one remembers that the phrase "50% in reserve" implies that, if necessary, the whole "100%" could be called into play for a short time. In present prism divergence requirements, however, if the examinee in question has 10 prism diopters of esophoria and constantly utilizes 10 prism diopters of divergence (negative convergence) to attain binocular single vision, an additional 10 prism diopters of divergence <u>cannot</u> be considered as the "50% in reserve" BECAUSE IT CAN NEVER BE CALLED INTO USE. This statement is made on the basis of evidence for a convergence center contained in AAF School of Aviation Medicine Project 375, Report 4 (20 July 1945). Never in his entire life does an individual actually use true divergence when fixating distant objects. It is therefore illogical either to attempt to test a function which is never used or to draw conclusions from tests of that same function.

On the other hand, AAF School of Aviation Medicine Project 139, Report 1 (2 November 1944) points out the extremely great value of prism divergence determinations made at the 13 inch distance. It is recommended that a minimum prism divergence (really negative convergence) of 15 diopters be required at this distance since this is the distance at which divergence is actually used and used often. It seems far more logical, apart from the wealth of factual evidence available to substantiate it, to test prism divergence at the distance where it is frequently called for, i.e., 13 inches, instead of at a distance of 20 feet where it is never used.

Prism divergence testing at 20 feet should be abandoned, while prism divergence testing at 13 inches should be required.

3. RED LENS TEST. AAF School of Aviation Medicine Project 322, Report 1 (21 December 1944) specifies a satisfactory shade of red for the test. Also brought out is the fact that the object of the red lens test is not to disrupt fusion at all but simply to aid a subject with diplopia to identify true and false images. The red lens specified in the report mentioned is at present in production by the Surgeon General for distribution to the Army Service Forces and Army Air Forces.

4. HETEROPHORIA AT 13 INCHES. There are at present no requirements for heterophoria determinations at any but the 20 foot testing distance. AAF School of Aviation Medicine Project 139, Report 1 (2 November 1944) points out that almost no competent ophthalmologist would attempt an analysis of any case without heterophoria determinations made at the reading distance. Such determinations are universally made in clinical practice. It is recommended that heterophoria testing at the 13 inch distance be incorporated in the "64" examination and the following limits are suggested:

a. exophoria, if present, not more than 15 prism diopters.
b. esophoria, if present, not more than 10 prism diopters.
c. hyperphoria, if present, not more than 1.5 prism diopters.

These recommended limits have been selected on the basis of an analysis of 250 cases. None of the cases who were comfortable in using their eyes and could, in addition, pass the rest of the visual portion of the "64" examination exceeded these limits.

5. SELECTION OF A HETEROPHORIA TEST. The test for heterophoria used in the Army Air Forces was apparently selected on the basis of studies made by Dolman (1920). It is a Maddox rod test with the addition of intermittent occlusion (screening) and is known as the screen-Maddox rod test. Since this test had been in use for 25 years, it was decided that it might be of value to determine its correlation with the heterophoria test universally regarded as being the most accurate, i.e., the screen and parallax test. This was done (AAF School of Aviation Medicine Project 375, Report 1, 13 April 1945), and the correlation coefficient of the two tests was found to be 0.81. It was concluded that, from the standpoint of correlation with the screen and parallax test, the screen-Maddox rod test was satisfactory. In this same report, correlation coefficients among other tests of heterophoria, both at 20 feet and 13 inches, were determined.

The next problem that arose was that of the reliability of the screen-Maddox rod test (AAF School of Aviation Medicine Project 375, Report 2, 20 July 1945). This was found to be 0.95. In this phase of the study, two separate examiners tested each subject on each of two separate days. The techniques of the two examiners were as nearly identical as was possible. All subjects were aviation cadets who, theoretically, had a visual acuity of at least 20/20 in each eye, a

normal amount of accommodation and convergence and heterophoria of not more than 1 prism diopter of hyperphoria, 10 prism diopters of esophoria, or 5 prism diopters of exophoria. The population available for study therefore represents a special selection from the general population with the consequence that the phoria readings extend over a limited portion of the entire range.

Another limitation arises from the frequency distribution of heterophoria which was not normal in form. A distribution for 131 subjects, tails out to the right (the statistic of skewness, $g_1 = 4.37$, is 6.5 times its own standard error; the statistic of kurtosis, $g_2 = 4.37$, is 10.4 times its own standard error). To test the normality of distributions still further, data were borrowed from Cridland (1941) for the purpose. In one of these (a Red-Green test) there is significant skewness to the right and in the other (a Maddox Rod test) there is significant skewness to the left. In all three distributions, there is significant leptokurtosis. The inconsistency of these findings suggests no general way of transforming the heterophoria scale to normality at this time. It may well be that in heterophoria, as in other biologic functions, there is no normal distribution in the sense of a smooth, bell-shaped curve.

Since the screen-Maddox rod test was found to be satisfactorily accurate (valid) and since it was found to be reproducible, the question of the effect of several possible variations in testing techniques arose. In AAF School of Aviation Medicine Project 375, Report 3 (20 July 1945), it was shown that there is no significant difference in heterophoria measurements when made with the screen-Maddox rod test in a lighted room or in a darkened one. Cridland (1941) was able to show the same thing for the Maddox rod alone, i.e., no difference between testing in light and dark.

Three other possible variations in technique were then studied. These were (a) screening vs. non-screening, (b) dominant vs. non-dominant eye, and (c) red vs. white Maddox rod. When intermittent occlusion (screening) is added to the Maddox rod test, there is a significant difference in the measurements. When testing at 20 feet, screening gives 0.3 to 0.4 diopters more esophoria than when screening is omitted. When testing at 13 inches, screening gives about 0.4 diopters less exophoria than when screening is omitted. The findings are comparable at both distances since a shift toward less exophoria is in the same direction as one toward more esophoria. The difference made by screening at both testing distances is consistent regardless of whether the Maddox rod is placed before the dominant or the non-dominant eye.

When testing heterophoria with the Maddox rod at distances of both 20 feet and 13 inches, there is no significant difference in the measurements when the rod is placed before the dominant eye and when it is placed before the non-dominant eye.

In the present Army Air Forces Physical Examination for Flying it is directed that the Maddox rod will be placed before the non-dominant eye in heterophoria measurements. The basis for the requirement is a paper by Captain Pere Dolman (Air Service Information Circular, 1:84, 15 August 1920). An analysis of Dolman's own data reveals that he too had found no significant difference with regard to ocular dominance but had simply misinterpreted his data.

When testing heterophoria at 20 feet, changing from a red to a white Maddox rod is equivalent to subtracting 0.25 diopters of esophoria from the measurement. This change is consistent regardless of whether screening is used or not and regardless of whether the rod is placed before the dominant or the non-dominant eye.

Determination of the dominant eye should be dropped entirely from the present physical examination for flying since there is no significant difference between measurements of heterophoria made with either eye fixing.

The screen-Maddox rod test could be abandoned in favor of the Maddox rod alone without sacrificing any accuracy for the following reasons:

(1) The screen-Maddox rod test has a reliability coefficient of 0.95 and that of the Maddox rod alone is also 0.95 (Cridland).

(2) The correlation of the Maddox rod test with the screen and parallax test is as high as the correlation of the screen-Maddox rod test with the screen and parallax test.

(3) It was recognized in World War I that exophoria in flying personnel is more productive of trouble than is esophoria. The omission of screening in the Maddox rod test tends to reveal more exophoria and less esophoria. This is desirable if, as has been stated, exophoria is more objectionable than esophoria in flying personnel.

(4) The testing technique of the Maddox rod alone is more easily made consistent among large groups of Flight Surgeons than is that of the screen-Maddox rod test. Such a standardization of technique would go a long way toward attaining consistent heterophoria measurements.

There is great likelihood of optical variation from one red Maddox rod to another because of difficulties inherent in the production method utilized. This is not true of the white Maddox rod and hence the white rod is recommended for standard use.

6. EVIDENCE FOR A CONVERGENCE CENTER. If esophoria and exophoria are separate entities, the independent existence of each is an argument for the existence of separate centers for convergence and divergence respectively. If, on the other hand, they are interdependent and have no separate existence, i.e., esophoria being the result of an increased convergence innervation and exophoria of a decreased amount of this same convergence innervation, then the evidence for a convergence center only is considerably strengthened while that for a divergence center is further weakened.

Adler (1945) has concisely expressed the results of two types of heterophoria tests .... "...various methods used to dissociate the two eyes will give different measurements, the amounts depending on the extent to which they eliminate the visual fusional stimuli. Heterophoria determined with the Maddox rod tells the effectiveness of dissimilar retinal images in holding the eyes straight as compared with the effectiveness of similar images. Heterophoria determined with the cover test tells how effective monocular retinal stimulation is as compared with stimulation of the two retinas simultaneously....."

The addition of screening to the Maddox rod to make the screen-Maddox rod test (Maddox, 1920; Dolman, 1920) results in a fairly effective combination of the factors quoted from Adler in the foregoing paragraph. With the screen-Maddox test, if esophoria and exophoria are separate entities, the added dissociation produced between the two eyes by screening should uncover <u>more</u> esophoria and <u>more</u> exophoria than when screening is not used. This is not what happens, however. Instead, screening uncovers more esophoria <u>but less exophoria</u>.

An inspection of the distribution of the 100 cases studied when the Maddox rod is used alone, if compared with the distribution of the same 100 cases when the screen-Maddox test is used reveals a striking fact. There has been no change in the shape of the distribution curve whatever, but simply A SHIFT TOWARD ESOPHORIA. This is factual evidence that exophoria and esophoria are not separate entities but merely varying degrees of the <u>same</u> entity.

With this concept in mind, the effect of the addition of screening now becomes understandable in the light of other known facts. The most important source of reflex activity in man comes from the visual impulses themselves (Adler, 1945). Because of the superior sensitivity of the fovea and its surrounding macula to the rest of the retina, the resultant fusion reflex (binocular) or fixation (monocular) occurs.

Considering anatomical factors alone, the two eyes should be divergent but in the absence of pathology, except in deep sleep or narcosis, the eyes never diverge but always converge in varying degrees. This convergence is a result of a constant convergence innervation arising from the convergence center (nucleus of Perlia). The presentation of dissimilar images of the same object to the two eyes by using

a Maddox rod over one eye dissociates the eyes only partially and the convergence center is thrown out of balance by a comparable amount. The addition of screening to the Maddox rod produces further and greater dissociation between the two eyes which in turn results in further and greater upset of the convergence innervation arising from the convergence center. The monocular fixation reflex is still acting powerfully since only one eye is being screened and the convergence center, in an attempt to correct for this added imbalance, responds with even more convergence innervation. The result should be — and is — increased esophoria or decreased exophoria depending upon which of the two was present from the beginning.

Thus the effect of the addition of screening to the Maddox rod test is explainable. More important, rather conclusive evidence is now available for the existence of a convergence center alone instead of separate centers for convergence and divergence.

B. COMPARISON OF MEASURES OF LATERAL PHORIA

Lt. Comdr. J. H. Sulzman

At the Medical Research Department of the U.S. Submarine Base, New London, Connecticut, four measures of lateral heterophoria are now under investigation.

The following methods are being applied to 100 subjects, each tested twice for lateral muscle imbalance at distances of 20 feet and 13 inches:

1. Maddox rod (white)
2. Maddox-screen
3. Screen and parallax

In addition, each subject was measured once on the Ortho-Rater.

Since the study is still in progress, a full report cannot be made at this time. Preliminary analysis indicates that from a standpoint of test-retest reliability at 20 foot distance, the three tests rank in the following order:

1. Maddox-screen
2. Maddox rod
3. Screen and parallax.

For the 20 foot distance, the coefficients of test-retest correlation for the Maddox-screen and Maddox rod methods indicate almost

equal test-retest reliability and the correlation between them is higher than the reliability coefficient for either one alone.

At the 20 foot distance, the Maddox rod test correlates with the other tests, in terms of Pearson coefficients of correlation, in the following order:

1. Maddox-screen
2. Screen and parallax
3. Ortho-Rater

The results outlined above are in general agreement with those reported by Capt. Scobee.

C. PHORIA TESTING AT PENSACOLA

Comdr. B. J. Wolpaw

The Department of Ophthalmology at the School of Aviation Medicine, Pensacola, Florida, is conducting a study in an attempt to determine the visual requirements necessary for military aviators. The subjects examined are all pilots who have returned from combat duty or have been pilots on transport planes flying outside the continental limits of the United States. The study embraces a great many examinations such as visual acuity, muscle balance for near and far, depth perception measured on the Howard-Dolman, Verhoeff Stereopter and Space Eikonometer. The subjects are also examined on the Bausch & Lomb Ortho-Rater, interpupillary distances measured on the NDRC Interpupillometer and retinal size differences are measured on the Vectograph Eikonometer.

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7. VISIBILITY THEATER

Capt. C. W. Shilling

The camouflage theater which was demonstrated to this group this morning was originally conceived by the Bureau of Ships as a device for the study of camouflage in its various aspects. They had in mind the study of the silhouette of ships, the study of contained shadows, the study of deception by the building of confusing superstructure. As an example of how it could effectively be used, this activity was recently engaged in the study of the very secret "X" paint being used in the problem of recognition between submarines and aircraft. In that particular project we used two submarines, a blimp, two airplanes, a surface ship to act as tender, and a number of personnel. In addition, we waited for the weather on a good many occasions. It is our firm conviction that this study could have been conducted in its preliminary stages at least, in a theater such as the model you have just seen. In the end, the cost of this project was almost sufficient, if one considers the salaries of the various people involved, to build a theater of this kind.

Visual problems in general could be handled in such a device as this. Perhaps some of you are not aware that a submarine operational research group worked in the night lookout training stage for many months studying the problem of the proper rate of scanning as related to the general problem of the lookout. This sort of activity could very easily be done in this theater where a great deal more realism would be possible and where the answers obtained would be much more acceptable from the standpoint of service validation.

It is conceivable that this theater could be used for studying some of the problems of air-sea rescue. I see no reason why the problem of the proper placement and selection of dye marking and signals could not be very effectively studied in the theater. Other problems of similar nature certainly could be solved here.

There are those who feel that optical equipment could, at least to a limited extent, be studied in this camouflage theater. This remains to be worked out by those people who are interested in, and who understand, this particular problem.

We visualize this camouflage theater to be a center of visual research having associated with it tunnels for the testing of optical equipment, dark rooms, laboratories, and all the facilities for handling visual problems, many of which have not been settled during the present war.

The personnel for this project should very definitely be widely diversified. We should have associated together the psychophysicist, the pure physicist, the physiologist, the psychologist, and,

in brief, someone representing every phase of visual and optical study. Thus we could develop a center for such work which would be recognized throughout the country as the one place where answers to the problems of vision could be obtained.

It must be clearly understood that no one associated with this theater looks upon it as any substitute for field testing. We look at it simply as a step between pure theory and laboratory experimental work, and actual field testing. Certainly there is a place for such an in-between step, for in this war the cost of many field experiments, which turned out to be either worthless or impossible of achievement because of inadequate tests and trials previous to the field experiment, has been such as to pay for this type of theater many times over. There must be some place to try out ideas other than in the fleet where the movement of ships becomes so very costly and complicated.

Discussion:

Lt. Comdr. Leavitt proposed a motion for discussion designed to convey Vision Committee approval of the development of the Visibility Theater project by the Navy Department.

In considering the motion several members pointed out difficulties involved in the development and use of such a theater for testing work, but all emphasized that the model and proposed uses of the theater warrant full support for the continuation of the project. Some of the problems mentioned were: validating the spectrographic distribution of light in the theater as compared with the actual field; simulating water surface conditions; preserving great flexibility in the design to enable adequate study of a wide variety of problems under all conditions.

The question of the specificity of the Vision Committee recommendation was discussed. Several members advocated a detailed outline of goals and proposed organization to be prepared by a subcommittee. Others felt that a strong resolution in favor of the Visibility Theater development by the Vision Committee would be more desirable. Concern was expressed regarding the need for the early selection of a highly-trained, experienced director of the project. Several members emphasized that the Visibility Theater should be a tool for a research center and that the director should be a director of a research program rather than of a facility.

As a result of the discussion, the following motion was unanimously adopted:

"The Army-Navy-OSRD Vision Committee believes it to be valuable and desirable for the Navy Department to provide facilities for visual research including building and operating a large-scale permanent visibility theater as a means of continuing active study of visual problems."

A Subcommittee on the Visibility Theater was appointed to formulate a statement embodying the discussion. Members are: Comdr. Charles Bittinger, Lt. Comdr. David Leavitt, Dr. H. K. Hartline, Dr. Loyd Jones, Dr. E. O. Hulburt, Dr. S. Q. Duntley, and Lt. Dean Farnsworth.

REPORT OF THE SUBCOMMITTEE ON THE VISIBILITY THEATER

I

Although visibility research has always been primarily a part of military activity, it has never been an adequate part of the military organization in peacetime. As a result, the two World Wars have found the armed services impoverished as to scientific answers to the many visual problems that present themselves. It is the hope of the Vision Committee in recommending this theater that a nucleus of laboratory workers will be formed to carry on actively the work which was incomplete at the end of the war. The Naval Research Laboratory, which was a connecting link in vision research between World Wars I and II, once stated in a report that the quantitative analysis of visibility data was in the field of the inexact and ambiguous sciences. However, in the many thousand variables which have been examined by a great many competent people in the present war, certain underlying consistencies have been observed, but a statistical reduction of data at the close of the war has not been accomplished. With the aid of the proposed visibility theater and its staff, not only will the vast amount of data and literature which has accumulated be utilized, but also the investigation of certain underlying factors and their application to military science can be carried on rather than abandoned at this time.

It was a whole year after the declaration of World War I before any camouflage was applied to our fighting ships. Although this time was slightly reduced in World War II, a clear-cut camouflage policy was not determined before war was declared. We were equally unprepared so far as other visibility problems are concerned. In order that these conditions shall not prevail in the event of another war, it is considered highly advisable that all methods of visual defense be studied during the peace interim.

The Visibility Theater was originally conceived by the Bureau of Ships as a device for the study of camouflage in its various aspects.

The model of this theater, which the committee has inspected and is reporting upon, was constructed by the Medical Research Department, U.S. Submarine Base, New London, Connecticut, and was financed by the Bureau of Ships.

II

1. The committee believes that the theater can be used in the following studies as a device for the investigation of:

> Ship camouflage by application of paint: Low visibility, course deception, range deception, silhouette.
>
> Ship camouflage by structural modification: Contained shadows, class identification, apparent course, silhouette, modifications to reduce the radar echo.
>
> Changes in naval architecture with reference to radar-controlled and homing missiles.
>
> Recognition devices.

2. This theater has the following uses as a device for the study of aircraft problems:

> Concealment of parked planes, runways, and hangars.
>
> Cockpit illumination, problems involving night rendezvous, and identification.
>
> Visible light analogues of techniques involving other frequencies of radiant energies.
>
> Study of counter action against guided missiles.

3. Preliminary stages of research in air-sea rescue, including visibility of signals, dyes, pyrotechnics, lights, fluorescent and phosphorescent materials, retro-reflectors.

4. The Visibility Theater will also be useful for the study of general visual problems, such as scanning procedures, lookout organization, design and uses of binoculars, goggles, and other optical equipment.

5. The theater can also be used for certain studies in aerology, such as the methods of expressing visibility factors and the design of transmissivity meters and methods.

6. Finally, this theater could be used for motion pictures and stills for demonstration and training, of both day and night effects, and for demonstration to interested officers to enact operational problems under various visual conditions.

III

The proposed establishment of a visibility research program in connection with a center incorporating the visibility theater raises questions of personnel. The staff of the proposed visibility project should be composed of representatives from all of the related visual sciences, that is, physicists, physiologists, psychologists, ophthalmologists, and statisticians. An organization composed of such members would be able to give proper direction to research and authoritative answers to all problems relating to vision and its application to warfare. The director should be a man of highest caliber and of the broadest experience in these related fields, and he should be a director of the research program and not of the facility alone. It is envisioned that the theater will be the central laboratory instrument of a long-range, comprehensive visual program.

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9. SYMPOSIUM ON GERMAN DEVELOPMENTS IN VISION AND OPTICAL DEVICES

A. GERMAN VISUAL DEVICES

Comdr. A. J. Vorwald

Before telling you of my observations in Germany relative to VISION and optical devices, permit me to digress a bit. I am pleased to be with you today if for no other reason than to compliment the Vision Committee for its enviable accomplishments and in addition to transmit an appreciation from the British Vision Committee. During my tour of duty in London as the Navy Medical Representative, I enjoyed repeated contact with that Committee and learned of their high regard for your work.

In addition to the primary mission of effecting medical liaison in England, my duties involved the investigation of German submarine and aviation medical targets as they became available for examination. These targets were scattered throughout Germany and in liberated countries. Many of the targets proved extremely valuable. Not only did we acquire instruments, records and documents relative to vision, but in many instances we were able to interrogate a number of vision experts captured with the target.

It is impossible to present a critical analysis of all our findings at this time. Many of them are still being studied and collated. Nevertheless, a few remarks are permissible.

Adaptometer after Engelking-Hartung. This captured German instrument was credited to Engelking and Brückner by Comberg in the Kurzes Handbuch für Ophthalmologie published in 1932.

The test subject viewed from a distance of 50 centimeters the circular ground glass plate transilluminated by white light of variable intensity. The curve of dark adaptation obtained by the instrument was then plotted logarithmically according to the method of Engelking (Klinische Monatsblätter für Augenheilkunde, 1933).

Two integrating spheres were evidently with this adaptometer. They were employed to produce a standard degree of light adaptation at the beginning of night vision examination.

Adaptometer after Comberg. Apparently this adaptometer was used to measure visual acuity in dim light immediately after full light adaptation. A distracting light source of the same brightness as the test field, or eight to sixty-four times that brightness, could be introduced to complicate the task for the subject being measured. The instrument is described also in the Kurzes Handbuch für Ophthalmologie, 1932.

Slit Lamp. This lamp by Zeiss was designed by W. Comberg. It is illustrated and described in the Klinische Monatsblätter für Augenheilkunde, 1933.

Color Perception Scoring Instrument. Interrogation disclosed that this instrument was developed in six days at the command of Goering, who was dissatisfied with the ordinary color charts used. It was admitted that the instrument was of little value, yet it had to be used.

The instrument incorporated a series of small colored discs so varied in intensity as to make it easy to determine the degree of color blindness present. A detailed description can be found in the Journal Deutsche Militärarzt for 1942.

Stereoscope. This instrument was equipped with viewing lenses of 10 cm. focal distance directed onto a movable frosted glass plate supported by a metal stand. The testing charts consisted of one with silhouettes and another with geometrical figures. The subject tested judged the distances of the various diagrams.

Phorometer. This instrument is still being examined. It is brought to your attention, however, to indicate that the Germans too were investigating eye declination.

Magnifying Spectacles. Interrogation disclosed that the Germans had developed spectacles with a small central cylinder for magnification. The spectacles were manufactured by Zeiss. Samples could not be obtained.

Contact Lenses. The Germans had tried such lenses but were forced to discard them because of the discomfort which they caused. Apparently the irritation and pain became intolerable after one to two hours' use.

Night Vision. Despite considerable effort, the Germans had failed to find any substance to increase night vision. Neither lipoid extracts of the retina, caffein, nor strychnine worked. Stimulation of other senses, exercising skeletal muscle, and use of supersonic waves (24,000 cycles/sec.) failed. The existence of a so-called new drug, "Liagtal B," to improve vision was denied. The opinion of all experts interrogated was that good living, exercise, adequate sleep, abstinence from drink, a minimum of tobacco, and, finally, training were the essential factors in good visual acuity.

In conclusion, a fair impression of the German activities relative to vision is reflected by certain contributions uncovered at a rather important Medical Research Institute located on the west coast of France. Documents acquired there disclosed that the Institute was in operation for more than three years. Only a few months before evacuating the Institute after D-Day, their researchers had concluded that

red spectacles were useful for pre-adaptation and that the inhalation of oxygen did not improve night vision. In view of the long period of research, certainly that record is not very impressive. This is not to say, however, that the German scientists had failed in other things.

In general, the evidence gathered throughout Germany forced the conclusion that the achievements of German medical research and development were in no case in advance of our own and in many instances definitely inferior to it. This is not in keeping with the proverbial German ingenuity in the field of scientific research and development. It must be realized that in many respects an obvious decline had taken place in their scientific accomplishments. Analysis of this decline disclosed at least four principal causes, namely: an adequate supply of scientists with ability was no longer available because many were in concentration camps or had been killed; intercommunication between scientists became more and more difficult until finally there was not the free interchange of thought so necessary for scientific progress; the supply of funds and of experimental animals was totally inadequate; and finally, freedom of action was rigidly curtailed by too much regulation from non-scientific authority.

B. OPTICAL DEVICES IN GERMAN ORDNANCE EQUIPMENT

Comdr. S. S. Ballard

The Bureau of Ordnance has taken an active part in the general program of obtaining and analyzing foreign ordnance equipment. A number of optical experts, both officer and civilian, have been detailed on temporary duty to the U. S. Naval Technical Mission in Europe and have visited most of the important optical targets on the European continent.

A large amount of optical equipment has been obtained, much of it off the shelf of the Zeiss works and hence new equipment in fine condition, and this has been or is being shipped back to this country. On arriving in this country an instrument is sent to the Ordnance Investigation Laboratory at the Naval Powder Factory, Indianhead, Maryland, where pictures are taken of it and a short report is written for circulation among all interested parties to describe the instrument very briefly. The purpose of these preliminary reports is simply to tell all hands what equipment is available, so that if a further and more detailed examination is desired it can be requested. An outstanding feature of these preliminary reports is the inclusion of X-ray photographs which show very clearly the optical elements as mounted in their mechanical framework. This is done with a special 2,000,000 volt Van de Graaff X-ray machine specially constructed for the project, or with lower voltage, routine X-ray equipment.

After examination of these preliminary reports, the Bureau of Ordnance directs the shipment of items to contractors' plants or to military establishments such as the Naval Gun Factory, the Naval Research Laboratory, or the National Bureau of Standards. Then the instruments can be entirely disassembled and all their properties, constants, features and measurements determined, and exhaustive reports prepared if such are desired.

The Bureau of Ordnance wishes to make this enemy optical equipment available for examination by any interested persons who are suitably qualified. Trips can be made to the Ordnance Investigation Laboratory by arrangement, or items can be shipped to your plant for examination.

Among the interesting points observed in German optical equipment examined to date are special rangefinder designs, the popular use of binocular telescopes and of wide-angle eyepieces, the use (probably in shore installations) of large, high-powered binoculars, and the frequent use of dual powered telescopes.

C. GERMAN GOGGLES, SUNGLASSES, AND DARK ADAPTOMETER *

Major E. A. Pinson

1. A German or French dark adaptometer which measures the threshold of dark adaptation objectively, making use of optokinetic nystagmus, thereby giving a result which is independent of any voluntary action on the part of the testee.

2. A German flying goggle (similar to the Army Air Forces B-7 Goggle) in which interchangeable lenses may be used, and for which the following lenses are available: A clear lens of 90% transmission, a neutral brown lens of "das umbral glas" of 18% transmission, and a metal insert which may be placed in the frame of the goggle. The insert may be opened and closed at will. When open it provides a wide field of vision; when closed it provides a narrow field of vision but gives protection from the glare of searchlights in which one may be caught. This metal insert also offers considerable protection to the eyes from small flying particles.

3. A goggle with adjustable red lens. The plastic red lenses are mounted on the frame of the goggle in such a manner that by the movement

* The foreign equipment described has been studied at the Aero Medical Laboratory, Wright Field.

of a small lever the lens is adjusted before the eyes and provides protection of dark adaptation of the wearer in bright light. This goggle has an overall transmission of 9%, with a transmission of less than 2% at all wavelengths in the visible spectrum shorter than 600 millimicrons. When the red lenses are adjusted upward a clear lens remains before the eyes of the wearer.

4. A dual-density goggle in which the transmission of the lower three-quarters of the lens is 25% and the transmission of the upper 1/4th of the lens is 1.5%. The lens is of the neutral brown "das umbral glas" in both upper and lower portions. This goggle would serve the same purpose as the Army Air Forces graded density flying sun glass, namely, that of permitting the wearer to scan the sky area very near the sun for enemy aircraft, while providing normal glare protection in the larger portion of the visible field.

5. A close-fitting goggle for dust and glare protection for ground personnel. The lens in this goggle has a transmission of 33% and is of the neutral brown "das umbral glas".

The neutral brown "das umbral glas" used by the Germans in all goggles, as discussed above, is made by the Zeiss Company and has transmission characteristics almost identical with that of the rose smoke glass used by the Army Air Forces in its standard flying sun glass. The principal virtue of this glass, in addition to glare protection, lies in its haze penetrating qualities according to the German description of its use. This corresponds to the Army Air Force experience with rose smoke glass.

A Memorandum Report No. TSEAL3-695-48K, subject, "German Dark Adaptometer," covers the adaptometer mentioned in the discussions at the Vision Committee meeting. A Memorandum Report is now in preparation which will describe the German goggles in detail.

D. DESCRIPTION OF ZEISS SUNGLASSES FOUND ABOARD A CAPTURED GERMAN SUBMARINE

Lt. Dean Farnsworth

The Zeiss sunglasses which were found aboard the captured German submarine U-858 are noteworthy in five respects:

a. Extreme density of transmission
b. Protection from peripheral glare
c. Variety of sizes available
d. Comfort of the cloth straps
e. Protective metal case

The transmission of the glass is calculated as 3% for average daylight. American officers wearing these glasses over a period of weeks did not find this a disturbingly low transmission. In fact, they were not aware that it was lower than the 10% to 15% goggles to which they had become accustomed. The description furnished with the sunglasses in 1942 described them as "dampening the brightness by about 75%," whereas the description furnished with the goggles here described—which was dated 1943—described them as "dampening the brightness by about 95%."

The frame is designed to fit the bony structure of the average face so closely as to exclude peripheral light. The frames are made of plastic. The rims are medium brown and the outside light guards are deep brown of less than 1% transmission.

The goggles were furnished in three sizes of frame, designated as 62, 65 and 68 mm. Probably the fitting to interpupillary distance is not important, but the variety of sizes permits a better fit for the purpose of excluding peripheral light.

The goggles are designed to be attached to the head by adjustable cloth tapes, the loops of which go around the ears. Careful instructions accompany a reserve pair of these tapes, telling how to adjust them properly. At first thought, it would be assumed that the tapes were devised as a substitute method due to shortage of metals, but the extensive use of metals in less important parts of similar equipment manufactured during this period suggests that the tapes were used because they were actually preferred. The goggles have been worn extensively by several American officers who find the above method of attachment comfortable and even preferable to the usual method.

The metal case is sturdy, nearly dustproof, and cloth-lined on the inside bottom to protect the glass surface.

The lenses have a greater vertical than horizontal curvature. The outside vertical curvature is +3.37, the outside horizontal curvature is +3.12. The inside curvatures are the negative of these measurements. The reason for the difference between the axial curvatures is not known, but it is probably the result of the manufacturing method. The surface irregularities exceed the acceptable standards of the U. S. Navy.

The accompanying instructions state that the "Umbralglass" is of a chemical composition which reduces infrared and ultra-violet to a safe degree. It may be assumed that as ordinary glass, it would eliminate the harmful ultra-violet. The following infrared readings were determined at the Research Laboratory of the Inter-Chemical Corporation:

at 743 $m\mu$	9.3% Transmission
at 775 $m\mu$	6.4% Transmission
at 805 $m\mu$	4.6% Transmission
at 850 $m\mu$	2.8% Transmission

The accompanying instruction sheet claims the following under "Capacity of the Umbralglasses" (literal translation): "The Umbralglass dampens the brightness by about 95% because of its strong coloring, and thus serves as a protection of the eye from glare. Edges and 'small points' (small objects) which otherwise appear 'covered by light' and veiled, come out more clearly. 'Rising ground and falling ground' (surfaces, levels, planes) are recognized better, distances seen more exactly. The Umbralglass is neutral brown, and thus gives the color picture of nature truly. The Umbralglass is of a chemical composition of a kind that also invisible infrared and ultr-violet rays, which often cause painful eye inflammations, are reduced to a nondamaging size."

The principal claims for Umbralglass can apparently be summarized by stating that it acts to some extent as a "haze cutter." This was tested by giving the F-M 100-Hue Test to four observers with and without goggles and there appears to be some slight justification for the belief that it would separate purple-blues from purple-reds to a bare extent. This, however, is at the expense of greatly reduced discrimination in the green to blue and in the yellowish-brown to purplish-brown color regions. It is questionable if the slight increased differentiation obtainable in one region is sufficient compensation for perceptual limitation in all the other regions.

F. GERMAN VARIABLE-POWER TELESCOPE

Lt. Harry London

In connection with the variable-power telescope received by Bureau of Aeronautics from Germany through ComNavMisEu, the following brief description of the instrument may be of interest:

The German telescope (name of manufacturer unknown) contains a variable magnification feature, ranging from 6 to 32 power. To achieve this change in magnification, a combination of lenses is designed to move within the barrel either toward the objective or toward the eyepiece with the separation between the lenses changing. The optical quality of the telescope is poor, but this is understandable in view of the wide range of magnification.

At 6 power the telescope may be used as a stadimeter. This is accomplished by a combination of two lenses, one positive and the other negative, each split along the vertical axis. Shifting one lens with respect to the other introduces prismatic effect while the power of the combination is unchanged.

It is planned to use this instrument in connection with tests in aircraft for determining the best magnification for drift sighting at various altitudes and various speeds. For this purpose a reticle will have to be incorporated at the focal plane near the eyepiece. The variable-power telescope may possibly be suitable for other applications requiring a wide range of magnification.

Minutes Army - Navy Vision Com

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SUPPLEMENT TO

MINUTES AND PROCEEDINGS

of the fourteenth meeting of the

ARMY - NAVY - OSRD VISION COMMITTEE

11-12 September 1945

Medical Research Laboratory
U. S. Submarine Base
New London, Conn.

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U.S. Armed Forces - NRC
Vision Committee

5. DESIGN AND TESTS OF RIFLE SIGHTS

C. TESTS OF RIFLE SIGHTS

Dr. C. J. Warden

The following summary of the paper presented to the Vision Committee describes work done under Contract OEMcmr-264.

The present report is concerned with the analysis of the visual task imposed by small arms marksmanship at different levels of illumination. This new line of investigation was begun on 1 June 1944 as Sup. 5 of Contract OEMcmr-264, and will end 30 November 1945. The primary aim of the study was to select the best possible set of rifle sights (rear, front) for use at the lowest level of illumination at which sighting is possible. The investigation falls naturally into two major divisions as follows: (1) the rear sight problem - Experiment I, and (2) the front sight problem - Experiment II. Complete information regarding apparatus, procedure, selection of subjects, and the like, will appear in a final report to the Committee on Medical Research to be submitted about 20 October 1945.

The data of this investigation support the following facts and conclusions:

1. The aperture type of rear sight (Garand) is far superior to the open or notch type (Springfield), when the size is properly adjusted to level of illumination. We recommend, therefore, that the aperture rear sight be employed exclusively on all types of rifles used by the Armed Forces of the United States.

2. The aperture of the rear sight must be increased in size as the level of illumination is decreased, in order to achieve maximum accuracy in sighting. The standard Garand sight, with an aperture 2.035 mm. in diameter, is extremely accurate at a level of illumination approximating sunset on a clear day. However, it is greatly inferior to a sight with an aperture 4.5 mm. in diameter at a level of illumination corresponding to 35-40 minutes after sunset on a clear day.

3. The size of the rear sight aperture, for maximum accuracy in sighting, is definitely related to the diameter of the pupil of the eye at a given level of illumination. It appears that the optimum size of aperture is about one-half the diameter of the pupil. This relationship held at both levels of illumination mentioned in paragraph 2 above.

4. The lowest illumination at which rifle-sighting can occur, under field conditions, is at a level corresponding to about 30-35 minutes after sunset on a clear day. This is true even when the bullseye-target, set at 100 yards, is made to represent the greatest contrast to be found

under actual conditions of combat, i.e., that of the soldier's face (bullseye) against the background (target) of trees, grass, ground, rocks, etc. Below this level of illumination, an effective sight picture cannot be had, so that only snap-shooting is possible.

6. At the lowest level of illumination at which sighting is possible, the optimum set of sights should have the following characteristics:

A. Rear sight. A closed sight with an aperture 3.5 mm. in diameter, with an aperture-rim ratio about the same as that found in the standard Garand rear sight (4.7:1). A narrower rim tends to fade out under low illumination.

B. Front sight. A post or bead sight with a flat face, about 2.9 mm. in width, with a white, gold, or other bright surface to give high visibility.

6. We recommend that all military rifles carry two sets of sights: (1) a set for ordinary day use, and (2) a set for use in dim illumination.

7. Such a double set of sights could be conveniently mounted on the same rifle by means of the following mechanisms:

A. The rear sight could be similar to the rear sight of the present carbine, with a 2.035 mm. aperture in one leaf, and a 3.5 mm. aperture in the other. A mere flip of this device would give a sight of the proper size for day or night use.

B. The two front sights could be mounted at an angle of 180 degrees, on a small steel turret, operated by a spring and fitting accurately into two square notches about 3/8 of an inch deep. The sights could be changed from an up or down position by pulling out the turret against the spring, turning it around 180 degrees, and inserting it again in the pair of notches. The sight not in use would be directly beneath the barrel, and hence out of the field of vision.

8. We recommend that a more exhaustive study be made of such front sight factors as brightness, size, and shape, as well as the bevel and reflector principles, in order to determine more precisely the optimum characteristics of the front sight for the dim level of illumination.

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9. SYMPOSIUM ON GERMAN DEVELOPMENTS IN VISION AND OPTICAL DEVICES

E. SOME NOTES ON VISUAL DEVICES AND PROCEDURES OBSERVED ON NEW GERMAN SUBMARINES

Lt. (jg) W. S. Verplanck

An examination of the equipment of two new German submarines led to the following observations of interest to the ANOSRD Vision Committee:

GENERAL ILLUMINATION

No special red night lighting of compartment space or instruments was found. Illumination levels were generally poor.

"Night" or emergency lighting was achieved by liberal use of a radium or phosphorescent paint around hatches and down hatchways.

No need was felt for night lighting because of the very limited occasions on which the sub was to be surfaced; dark adaptation was produced by the use of red goggles.

LOOKOUT WATCHES

The lookout watch was of four men, on watches of four hours' duration; however, the limited duration of periods when the submarine was expected to be surfaced, reduces this lengthy watch to more orthodox proportions.

LOOKOUT EQUIPMENT

Each submarine carried approximately twenty 7 x 50 waterproof binoculars. Evidence indicates that one was assigned to each individual using binoculars, for his regular use. Optically, these seem very similar to those of the U.S. Navy, and have no advantage over them. Mechanically, they are solidly built, with protective rubber casings so located that it is possible to drop them without harm. A guard, attached by a rubber cable to the hinge, protects the eyepieces from dust. Focussing is performed by manipulation of a set screw alongside the eyepiece.

OTHER BINOCULARS

An 8 x 60 waterproof binocular has also been examined. Its field seems to be approximately 6 degrees. This specimen does not have rubber casing, although the eyepiece guard is affixed. Fixed focus (-FD)

PERISCOPE

Attack periscope: Mechanically, or better hydraulically, this periscope is exceptionally good. The observer sits on a saddle built from the side of the scope and is able to control the bearing toward which the periscope is directed by the use of convenient foot pedals which operate by hydraulic gear. A hand lever at the left raises and lowers the periscope head without affecting the position of the eyepiece, and consequently of the observer. A second lever, on the right, controls the elevation of the line of sight, for search of sky or surface, and to maintain the horizon in the center of the periscope field despite roll and pitch.

The variable extension of the scope, with unchanged eyepiece, is effected by a prism which is geared to the periscope head. This prism is a massive and beautifully polished chunk of optical glass.

The instrument is internally heated, as are all fixed optics aboard. Either of two filters may be placed in the optical system, an amber of high transmission, and a very light green. No "haze" filter was used.

Optically, this periscope presents no unusual features, except that the field is by no means uniform; the outer portion of the field yields an image of poor resolution when the center of the field is in proper focus. It is possible that this poor field is peculiar to the particular periscope examined, which needed draining.

Approximate data are as follows:

	Low Power	High Power
Magnification	1.5	6.0
Exit pupil	3-4 mm* (app)	3-4 mm (app)
Field	28°	7°
Range of elevation	-15° to +20°	

Remarks: Eye distance critical; poor eye cup; 3-4 degree error in the azimuth scale which appears at the top of the binocular field; illuminated reticle; difficult to achieve good focus.

It is not surprising that those who had used it remarked that "you can't see at night" through it.

An interesting device was employed on this periscope to eliminate the wake or "feather" produced by raising it above the surface of the sea. A set of three or four heavy cables, twisted about the neck of the scope, served to "spin" the water through which the periscope moved, thus minimizing the wake produced.

* Accurate determinations of exit pupil were impossible, as were any precise measurements.

<u>Search periscope</u>: This periscope is more conventional mechanically, lacking both the hydraulic drive and the fixed eyepiece, but it is far better optically.

The principal feature is a beam-splitting device permitting binocular as well as monocular viewing, with independent focusing for each eye. These images are of unequal brightness. A very large exit pupil and an extraordinary range of elevation of the line of sight also characterize the periscope. The same filters are available as in the attack periscope.

Basic characteristics are as follows:

	Low Power		High Power	
	Monocular	Binocular	Monocular	Binocular
Magnification	1.5	1.5	6.0	6.0
Exit pupil	8 mm(app)	Slightly less than 8 mm	8 mm(app)	Slightly less than 8 mm
Field	38°	$38^\circ x 30^\circ$	9°	$9^\circ x 7.5^\circ$
Range of elevation	-10° to 90°		-10° to 90°	

The field is exceptionally bright and clear; no differences in definition are apparent across the field. Visually, this periscope is an exceptionally fine instrument.

GUNSIGHTS

Each of the anti-aircraft machine guns is fitted with a 1 power sight. The field of view is 38° in diameter.

The reticle of this sight consists in a set of radials spaced at intervals of approximately 30°. These overlap a set of four ovals. The central portion of the field, approximately 10° in the horizontal axis, is open.

ABSTRACTS

101. FINAL REPORT ON VISIBILITY TESTS OF SPECULAR AND NON-SPECULAR EXTERIOR AIRCRAFT SURFACES. PART II: THE ALL-OVER GLOSSY SEA BLUE AND THE BASIC, NON-SPECULAR AIRCRAFT CAMOUFLAGE SCHEMES.

S. E. Garrett and H. F. Cross. U. S. Naval Air Station, Patuxent River, Md. Project TED No. PTR-2556, 14 May 1945, 24 pp. (Restricted).

All-over Glossy Sea Blue and the Basic, Non-specular aircraft camouflage schemes are compared for visibility ranges as seen against the sky and the sea. The Basic, Non-specular camouflage was designed to be of as low visibility as possible when seen from any direction against sea, carrier deck, or sky backgrounds. Four lacquers are used: semi-gloss sea blue (3% reflectance); non-specular sea blue (3%); non-specular intermediate blue (21%); and non-specular white (65%). The all-over glossy sea blue coating has an average reflectance of 3 %. It is concluded that: (a) As observed in side view against the usual variety of sky backgrounds, there is no appreciable difference in the distances at which aircraft painted these two camouflage schemes can be seen. (b) As observed from above over sea backgrounds, aircraft painted these two camouflage schemes are both very effective and about equally difficult to see. (c) When flying at the usual low and medium altitudes and observed from below against the zenith and high sky backgrounds, aircraft painted the Basic, Non-specular camouflage scheme are decidedly more difficult to see than those painted the All-over Glossy Sea Blue.

102. AERIAL TARGET RANGE ESTIMATION

M. W. Horowitz and W. E. Kappauf. Applied Psychology Panel, NDRC. Project N-111, Report No. 4, Contract OEMsr-815, OSRD Report No. 5301, 3 July 1945, 7pp. (Restricted).

Data have been obtained on the accuracy of unaided visual range estimation for aerial targets at ranges between 1500 and 8000 yards. The groups of subjects were small, but the data were consistent in indicating that untrained men make estimation errors which average 30% of true range or more, whereas trained men make errors which may average no more than 20% of true range.

There was a definite trend in the estimates such that long range targets were underestimated relative to short range targets. Similarly there was a tendency for outgoing targets to be underestimated relative to incoming targets.

103. DISTORTION IN GLASS AND ITS EFFECT ON DEPTH PERCEPTION.

S. Schachter and A. Chapanis. Air Technical Service Command. Eng. Division. Aero Medical Laboratory. Memorandum Report TSEAL3-695-48B, 27 April 1945, 39 pp. (Open).

This report forms a part of a coordinated research program on visibility requirements of transparent areas. It deals with the effects on depth perception of sighting through five samples of glass containing graded amounts of distortion. An experiment was run with the five samples of glass at five angles of incidence, 0°, 20°, 40°, 60°. Six subjects were each given ten trials on the Howard-Dolman depth perception test with each of 25 sample-angle combinations. A second experiment was designed to check the validity of the first and to correct certain flaws in the original experiment. Provision was made for no-glass trials. The two sets of data are in essential agreement and support the following conclusions: (1) Depth perception, as measured by the Howard-Dolman apparatus, is impaired when pieces of glass which contain distortion are placed in the line of sight. At all angles of incidence the amount of impairment is directly proportional to the amount of distortion in the glass. (2) Large angles of incidence increase distortion and decrease depth perception markedly for all glass samples. The difference between the amount of distortion at a large angle of incidence, e.g., 70°, and distortion at a small angle of incidence, e.g., 20°, is much greater than the difference in distortion between a Grade A and Grade C type glass viewed normally. (3) This impairment of depth perception is not caused by simple deviation and/or loss of transmission through the glass at large angles of incidence. Appendices give details of both experiments.

104. NIGHT VISION TESTING AND TRAINING IN THE ARMY GROUND FORCES.

A. Chapanis. Hqs. Air Technical Service Command. Eng. Division. Aero Medical Laboratory. Memorandum Report TSEAL3-695-48E, 1 July 1945, 27pp. (Restricted).

Observations on the night vision testing and training program in the Army Ground Forces are summarized in this report. It is concluded that the testing part of the program can be improved and extended. Comparison is made between the Radium Plaque Night Vision Tester and the Army Night Vision Tester-Trainer, used in the AGF program. The correlation between the two tests is high, r = +0.67; the RPNVT is

simpler, more rugged, and a large group of men can be tested in less time than is required for the ANVT-1. The training program is described (see Proceedings, twelfth meeting, pp. 56-61) and is thought to be complete and thorough. Observations on a number of devices for improving vision at night are also discussed.

105. TESTS OF REFLECTION-REDUCING COATING (AMERICAN OPTICAL CO. 157C-50) ON BULLET-RESISTANT GLASS FOR MODEL F6F-3N AND F6F-5N AIRPLANE.

D. H. Kelly, J. Plunkett, and H. F. Cross. U. S. Naval Air Station, Patuxent River, Md. Project TED No. PTR-2583, 9 May 1945, 18pp. (Restricted).

A two solution reflection-reducing coating (157C-50, one of several types of colloidal silica suspensions developed by the American Optical Company) applied to the bullet-proof windshield of a F6F-5 night fighter was evaluated for visual ranges, glare reduction, cleaning and maintenance. Details of flight tests and ground tests are given and photographs are included. None of the tests conducted showed a positive advantage for the coating over the standard windshield now in use, while several tests indicated definite disadvantages.

106. EFFECTS OF INCREASED INTRAPULMONARY PRESSURE ON DARK ADAPTATION

Charles Sheard. National Research Council. Committee on Aviation Medicine. CAM Report No. 449, 28 May 1945, 7 pp. (Open).

The present studies on the effects of increased intrapulmonary pressure on the threshold levels of cone and rod adaptation show that, using positive pressures of 4 or 8 inches water (7.5 and 15 mm. mercury pressure) at high altitudes (from 36,000 feet), there is a maintenance of maximal sensitivity to light and of the best levels of rod and cone adaptation which are possible under the conditions imposed. At high altitudes (42,000 to 45,000 feet), without increased intrapulmonary pressure, there may be a change of 0.75 to almost 1 log unit in the rod threshold, indicating a five- to tenfold increase in the amount of light needed to produce a response as compared to the threshold values at ground level. In general, there is less effect of pressure breathing on the cone adaptation than on the rod adaptation, since there is a greater effect of anoxia per se on the rods in the periphery than on the cones at the macula. These investigations show that, with increased intrapulmonary pressure at high altitudes, it is generally possible to maintain the threshold levels of rods and cones at the same values respectively as were obtained initially at ground levels breathing air or at altitudes under 30,000 feet while breathing oxygen.

107. THE SELECTION OF FIRE CONTROLMEN (O) RANGEFINDER AND RADAR OPERATORS.

D. C. Beier and F. Gray. Applied Psychology Panel, NDRC. Project N-114, Report No. 19, Contract OEMsr-1171, OSRD Report No. 4261, 26 March 1945, 35 pp. (Restricted).

This report presents the results of an experimental analysis and validation of selection requirements for the selection of Fire Controlmen (O), Radar and Rangefinder Operators. In general, the study consisted of an investigation of the predictive relationship of various paper and pencil tests and various visual tests (administered prior to or upon entrance) to graduation achievement and performance criteria.

Various tests were examined and validated against criteria developed by project N-114. The various analyses are based on groups of 56 to 288 students at the Lauderdale School. The basic method of analysis used in the present investigation is to construct four-fold tables of passing and failing groups in terms of test and criterion scores. This type of analysis provides a measure of the usefulness of a test as a selection instrument at different cut-off scores. Bar diagrams are presented to afford ready comparison of the principal results for individual tests and combinations of tests. Finally, chi square is used to evaluate the distribution represented in the four-fold tables and its magnitude indicates the likelihood that the observed distribution could arise by chance.

After investigation of many possible combinations of the tests at various cut-offs, it appears that in terms of selection and instruction cost and other practical considerations, the following two batteries yield the most satisfactory results:

<u>Battery No. 1</u>

a. General Classification Test: 50 and above;
b. Arithmetic Test; 45 and above;
c. Ortho-Rater Visual Acuity worse eye score: 9 or greater;
d. Ortho-Rater Vertical Phoria score: not less than 4 nor more than 7 (Heterophoria not greater than ½ prism diopter);
e. Ortho-Rater Lateral Phoria score: not less than 4 nor more than 12 (Esophoria not greater than 3½ prism dopters, Exophoria not greater than 4½ prism diopters);
f. Multiple Projection Eikonometer Test score: 58 or greater.

<u>Battery No. 2</u>

a. General Classification Test: 45 and above;
b. Arithmetic Test: 55 and above;
c. Ortho-Rater Visual Acuity worse eye score: 9 or better;
d. Ortho-Rater Vertical Phoria score: not less than 4 nor more than 7 (Hyperphoria not greater than $\frac{1}{2}$ prism diopter);
e. Ortho-Rater Lateral Phoria score: not less than 4 nor more than 12 (Esophoria not greater than $3\frac{1}{2}$ prism diopters, Exophoria not greater than $4\frac{1}{2}$ prism diopters);
f. Ortho-Rater Depth score: 5 or greater.

The results of both final batteries have been tested for statistical significance and more than satisfy the 5% level of confidence. This is true for Class 6 (N = 56), for Class 7 (N = 90) and for the two classes combined (N = 146). Consequently, similar results can be expected with reasonable certainty for similar samples of the general Navy population.

The visual selection standards in the two batteries apply only to rangefinder operation. Because there were no satisfactory criteria of radar operator performance, no selection standards of near visual acuity were validated.

108. GROSS ERRORS IN READING SCALES OF PANORAMIC TELESCOPES.

L. V. Searle and K. S. Wagoner. Applied Psychology Panel, NDRC. Project SOS-11, Report No. 1, Contract OEMsr-581, OSRD Report No. 4934, 13 April 1945, 21 pp. (Restricted).

Observations using four panoramic sights (1) an M-12, the standard instrument of the American Field Artillery; (2) an M-12 sight with a modified coarse azimuth scale; (3) a modification of the M-12 sight constructed at the Armored Medical Research Laboratory at Fort Knox, Ky; and (4) the German sight Rbl-F-32 were made to study the occurrence and prevention of gross errors in reading the scales of panormaic telescopes. Eight lieutenants and 72 enlisted men, varying widely in their experience in gun pointing, were instructed to make twenty readings from each of the four instruments, the first four readings with each sight constituting a practice series, and the other 16 readings with each sight constituting a test series, for each individual. A total of 6264 readings were made, 1256 practice trials and 5008 tests. The 5008 tests include about 1248 tests for each of the four instruments.

Compared with other instruments used in this study it is found that gross errors in reading the scales of the M-12 panoramic sight are excessive. Most of these errors can be accounted for either (1) in the use of a coarse azimuth scale or (2) in the design and manufacture of the coarse azimuth scale and other parts of the instrument. That the use of a scale for coarse azimuth readings is the primary factor in the occurrence of 100 ⌀ errors is demonstrated by the few such errors made with the use of the A.M.R.L. modified M-12 sight in which a scale is not used for coarse azimuth readings. The same officers and men who made 105 100 ⌀ errors in reading the scales of their own M-12 sight, after four practice trials made only eight such errors on the A.M.R.L. modified M-12 sight, and after ten practice trials made no gross errors at all. The effects of good design and manufacture may be seen in the results with the German sight. In this instrument the effects of dirt and wear are at a minimum, the background does not chip, the indicator and lines demarking the scale divisions are finely engraved, and every second scale division is numbered. Other large errors, although not specifically remedied in the A.M.R.L. and German sights, tend to disappear with their use. This indicates that, with instruments easier to use, these errors will occur less often.

109. THE RELATIVE EFFECTIVENESS OF A CHECK SIGHT TECHNIQUE COMPARED WITH TWO OTHER METHODS USED IN TRAINING GUN POINTERS ON THE 40 MM GUN EQUIPPED WITH THE COMPUTING SIGHT, M7.

J. H. Rapperlie. Applied Psychology Panel, NDRC. Project SOS-6, Memorandum No. 12, Contract OEMsr-581, O.S.R.D. Report No. 4975, 25 April 1945, 11 pp. (Restricted).

By means of a Position Sampling Method, three groups of ten 40 mm gun pointers were equated on the basis of pre-training check sight scores. Subsequently, each group was trained by one of three different methods: a Check Sight Method, a Verbal Coaching Technique, or a CO-Tracker Guidance Method.

With the Check Sight Training Method, an observer first noted the tracking errors of the gun pointers by using a plexiglass check sight and then notified the gun pointers of these errors by means of a buzzer signal. With the Verbal Coaching Technique an officer made suggestions to the gun pointers during their training period. With the Co-Tracker Guidance Method one of the gun pointers served as instructor or coach as well as tracker in that he indicated the errors of the other tracker as he perceived them.

Comparison of the three groups after their respective training periods indicated that the greatest improvement in tracking performance was made by the group trained with the Check Sight Method. The Co-Tracker Guidance Method was more effective than the Verbal Coaching Technique.

Advantages and disadvantages of the three training methods are here presented.

It is recommended that the check sight technique be used more widely in training gun pointers when using the Computing Sight M7.

110. EVALUATION OF A PLEXIGLAS CHECK SIGHT AS A TESTING AND TRAINING AID WITH GUN POINTERS ON A 40 MM GUN EQUIPPED WITH THE COMPUTING SIGHT M7.

G. E. Brown, Jr. Applied Psychology Panel, NDRC. Project SOS-6, Memorandum No. 14, Contract OEMsr-581, OSRD Report No. 4977, 23 April 1945, 13pp. (Restricted).

An evaluation was made of the reliability and the validity of a Plexiglas Check Sight as a device for testing on-target tracking with a 40 mm. gun, and of its use as an aid in training gun pointers for on-target tracking. The Plexiglas Check Sight scores are found to have reliabilities and validities of such a magnitude that the scores are useful in determining the relative standings of individuals in a group only if wide range of tracking abilities are being tested. The Plexiglas Check Sight is valuable as a training aid.

111. A STATISTICAL SURVEY OF RESULTS OF NIGHT VISION TESTING IN THE ROYAL NAVY BY THE METHOD DESCRIBED IN CAFO. 1673/44.

Admiralty Research Laboratory. A.R.L./N.2/84.07/0, 11 January 1945, 22pp. (Confidential).

The decision in August 1943 to test all new entries to the Royal Navy for night vision and to classify personnel into three groups (1) night vision tested, (2) poor night vision, and (3) very poor night vision resulted in the development of a rapid method for testing. The method, described in this report, was designed to place all night blind personnel and some with seriously defective night vision in class 3 (not more than 1%); all border-line cases in class 2 (about 3% of personnel). A total of 37,640 men have been tested. A little less than 1% of those for whom complete results are available have been classed VPNV and a little less than 2% have been classed PNV. It is shown that there is no significant correlation between night vision grading and the results of intelligence tests.

112. EXPERIMENTAL LIGHTING DEVICE FOR IDENTIFICATION, RENDEZVOUS, AND FORMATION FLYING.

G. M. Greene. U. S. Naval Air Station, Patuxent River, Md. Project No. PTR-31782.0, 25 April 1945, 4pp. (Confidential).

A clear polished lucite rod 3/4 inches in diameter and 42 inches in length with white dots painted on the surface to scatter light was flight-tested to determine its value for identification, rendezvous, and formation flying. The conclusion that the lucite rod is an improvement over present lights is based on the following results: (a) The linear form of the rod was visible for three miles; beyond five miles, it became a point source of light of very low intensity. (b) The airplane's relative speed and direction were very easy to observe. At ranges encountered in formation flying, the rod is easily visible and may be used without the navigation lights. (c) The use of the lucite rod for formation and rendezvous flying is beneficial to the maintenance of security. At its maximum brilliance, when viewed at a distance, the rod is less perceptible than the navigation lights. (d) Coding of the rod can be very easily accomplished by the use of bands of tape, at a sacrifice of range, or changes of color in the light source.

113. AN INVESTIGATION OF THE RELATIVE ACCURACY OF FIVE METHODS OF TRACKING AERIAL TARGETS USING MARK 12 RADAR.

C. C. Befer and H. A. Taylor. Applied Psychology Panel, NDRC. Project N-114, Report No. 20, Contract OEMsr-1171, OSRD Report No. 4927, 16 April 1945, 12pp. (Confidential).

This research report concerns the question as to which oscillograph presentation or combination of presentations available to trackers in Mark 12 radar provides the most accurate tracking. These presentations may be either spot on crosshairs, pips matched in height, meter with pointer, spot combined with meter, or pips combined with meter. Two separate sets of data were collected; the first during a preliminary experiment from a group of 15 student operators in their two-week training period on a Mark 12 training mount; and the second from a group of 28 student operators during the last two weeks of their 16-week course, in the gun director Mark 37 with Mark 12 radar. The latter group had had considerable training in director operation and Mark 12 radar, the former group had had no training in the gun director, and only four hours of training in Mark 12 operation at the beginning of the experiment. Analysis of these two sets of data was directed toward determination of the relative accuracy of the five methods of tracking with Mark 12 radar, whether in the Mark 37 gun director or training mounts.

Analysis showed signficiantly less accuracy for trainers in the case of pips than for any other method, and no significant difference in accuracy for pointers by any of the methods. The rank order in terms of least number of target losses for trainers was: (1) spot, (2) pips and meter, (3) spot and meter, (4) meter, (5) pips; and for pointers, (1) spot and meter, (2) pips and meter, (3) spot, (4) meter and (5) pips.

Other reports received, which may be secured or consulted in the Office of the Vision Committee:

114. Great Britain. Medical Research Council. Military Personnel Research Committee. Subcommittee on Armoured Vehicles. B.P.C. 44/340/P.L. 136, May 1944, 6pp.

Factors which reduce visibility of targets when a telescope graticule is illuminated are discussed and their effects have been calculated.

115. Great Britain. Ministry of Supply. Advisory Council for Scientific Research and Technical Development. Fighting Vehicle Armament Research and Development Committee. Tank Armament Research Report No. 33, 21 June 1945, 9pp.

Trials were carried out using a Ross variable power telescope to determine the best compromise between magnification and field of view. It is concluded that the optimum setting lies in the region of 5X to 7.5X magnification.

116. Great Britain. Royal Air Force. Operational Research Section. Coastal Command. ORS/CC Report No. 317, 23 October 1944, 10pp.

Extensive experiments to determine the comparative visibility and conspicuity of the possible colours for air-sea-rescue equipment.

117. Great Britian. Ministry of Supply. Advisory Council for Scientific Research and Technical Development. Armament Research Department, Fort Halstead, Kent. A.R.D. Explosives Report No. 410/45, March 1945, 7pp.

Some calculations on the effect of mixing light of different colours, with reference to the colour quality of the flames from pyrotechnic signal compositions.

118. A GERMAN DARK ADAPTOMETER

Chapanis, Alphonse and Richard O. Rouse. Air Technical Service Command. Engineering Division. Aero Medical Laboratory. Memorandum report TSEAL 3-695-48K, 5 September 1945, 8 pp. (Open)

Description is furnished of a German instrument for measurement of the extent of dark adaptation. The ability of the eye to detect brightness differences is measured not by the usual report of the subject but by the presence of a reflex. A moving pattern is arranged so as to elicit optokinetic nystagmus. It is assumed that the presence of this reflex is related to the perception of brightness contrast, ordinarily measured in adaptometers. The liminal illumination of the moving pattern is determined at various stages of adaptation, utilizing as criterion the presence of nystagmus.

The use of an objective measurement of the extent of dark adaptation is valuable in the case of children and subjects who are uncooperative or cannot understand instructions. The German instrument is not satisfactory in performance. Changes are suggested by which the technique could become useful for laboratory and clinic. Large scale testing is impractical, however, because subjects can be examined only singly.

119. NIGHT VISION — A REVIEW OF GENERAL PRINCIPLES

Chapanis, Alphonse: The Air Surgeon's Bulletin, 2, 1945 (September), 279-284 (Open)

Diverse visual phenomena are discussed in order to explain equipment and procedures which have been standardized for Air Forces personnel. Equipment covered includes: dark adaptation goggles, sun glasses, oxygen regulators, cockpit lighting units and binoculars. Procedures which are explained include: dark adaptation, personnel selection by means of the Hecht-Shlaer Adaptometer, prevention of carbon monoxide concentrations in cockpits, use of supplementary Vitamins A (and C), use of off-center vision, maintenance of clean transparent sections when binoculars are used and use of shifting fixation to avoid visual illusions.

120. AAF NIGHT VISION TRAINER

Training Aids Division, New York City: The Air Surgeon's Bulletin, 2, 1945 (September), 284 (Open)

A projection apparatus is described, modeled after the RCAF Evelyn trainer, to provide simulated conditions of night viewing. Provision is made for the exhibition of stationary objects and in addition

both slow moving and rapidly moving objects. Aircraft silhouettes can traverse the field horizontally or diagonally. Means of adjusting the brightness of the simulated sky are provided as well as means for simulating haze and fog. Weight 130 pounds. Operates on 110 v. A.C.

121. AML PORTABLE RADIUM PLAQUE NIGHT VISION TESTER

Pinson, Ernest A., and Alphonse Chapanis: The Air Surgeon's Bulletin, 2, 1945 (September), 285 (Open)

An instrument is described, designed to enable the flight surgeon to obtain a measure of night vision in a simple manner. Field illumination is provided by a radium plaque. The test object is a Landolt ring, whose orientation is reported by the subject from various distances. Although the chief advantage of this instrument is its convenient size (5-3/8 x 6-3/4 x 3/4 inches), tests have indicated instrument stability and reliability of test score. A chart is presented by which scores on this instrument can be related to scores on standard instruments used in testing the adequacy of night vision.

122. A NIGHT VISION TRAINER

Pinson, Ernest A., Chapanis, Alphonse and Stanley Schachter: The Air Surgeon's Bulletin, 2, 1945 (September), 286-287 (Open)

A simplified apparatus is described, intended to simulate conditions of night viewing for testing at installations where the <u>AAF Night Vision Trainer</u> (Abstract 120) is unavailable. Provision is made for the exhibition of stationary objects and objects movable by manual control. Variable brightness of the simulated sky and simulated haze and fog are possible. All materials necessary for construction are readily available from stock. Operates on 1.5 v.

123. A CASE OF NIGHT BLINDNESS

Hinn, George J. and Rocco A. Montano: The Air Surgeon's Bulletin, 2, 1945 (September), 287 (Open)

A case history is reported, describing an experienced pilot whose night flying was noticeably deficient. Ordinary ophthalmological examination did not reveal marked aberrations. Clinical examination on the Evelyn two-dimensional night vision trainer and the Radium Plaque Adaptometer revealed extremely poor night vision. A test made with the American Optical Projector indicated very poor regeneration of visual purple. In addition, the patient had a history of continual, unprotected exposure to high brightnesses.

124. THREE CASES OF DEFICIENT NIGHT VISION

Chapanis, Alphonse and Richard O. Rouse:
The Air Surgeon's Bulletin, 2, 1945
(September), 288 (Open)

Three case histories are reported concerning experienced pilots whose night flying was unsatisfactory. Each obtained a markedly unsatisfactory score on each of the night vision tests administered. Tests were made for at least one patient on each of the following instruments: Hecht-Shlaer Adaptometer, Radium Plaque Night Vision Tester, SAM Portable Night Vision Tester, AAF-Eastman Night Vision Tester. In no case was there a visual anomaly detectable by ordinary ophthalmological examination.

One patient was returned to normal function by the administration of "massive doses" of vitamin A although there had been no history of dietary deficiency.

Although the three patients exhibited similar deficiency in function, they differed significantly in their realization of their deficiency. It is explained that deficiency is not recognized because of the rare use of night vision in ordinary activities.

125. HUMAN FACTORS IN AIRCRAFT DESIGN

Gagge, A. P.: The Air Surgeon's Bulletin,
2, 1945 (September), 298-301 (Open)

In the design of current aircraft, scant consideration was given to problems of human physiology. As a consequence, aviation physiologists and flight surgeons have attempted to insure maximum aircrew efficiency by developing personal equipment intended to offset failures in basic aircraft design. It is clear that, in the development of future aircraft, the limiting factors will often prove to be physiological.

To obtain maximum visual efficiency, care must be taken to provide the highest quality optical material for windscreens and sighting blisters. Further, design should insure that the line of vision passes through the optical materials at near normal incidence. Inadequate design will result in loss in range of vision, loss in depth perception and inadequacy of night vision.

126. IMPROVISED EYE TEST INSTRUMENTS

Rhoads, S. C.: The Air Surgeon's Bulletin, 2, 1945 (September), 308 (Open)

Three devices are described and illustrated, designed for improving measurements of interpupillary distance, near point of convergence and accommodation.

127. THE ADVANTAGES OF USING BINOCULARS FOR NIGHT SEEING

Brackett, Frederick S; Roberts, Lester B. and Wendell E. Mann. Armored Medical Research Laboratory. Partial Report on Project No. 6-1, SPMEA 741-12, 24 March 1945, 9 pp. (Open)

The distance at which targets are recognized on a moonless night was determined as a function of magnification and exit pupil diameter of various binoculars. Tests were made using a Landolt ring, the orientation of which was reported under each experimental condition. The effect of magnification was determined by using three instruments. The effect of exit pupil was studied by inserting various stops at the objectives of two of the three instruments. Under each experimental condition, the distance was determined at which the test target was liminally detected.

It was found that the recognition distance increased with an increase either in magnification or exit pupil diameter. Approximate data on the three instruments indicated a 3.5 increase for an Army 6 x 30 (M3) binocular, a 4.8 increase for a Navy 7 x 50 binocular, and a 5.7 increase in recognition distance for a 10 x 45 B.C. scope. Proportional advantage was obtained regardless of whether a monocular or binocular instrument was used.

By interpolation and extrapolation of the data, the optimum ratio of objective diameter / power was determined to be 3, for all magnifications tested.

It is emphasized that other factors were not considered, the most important of which was probably the size of field. The use of high magnification is often impractical because of image motion and the difficulty encountered in searching. The maximum practical exit pupil is usually considered to be 7 mm.